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CANADA
DEPARTMENT OF MINES
HON. CHARLES STEWART, MINISTER; CHARLES CAMSELL, DEPUTY MINISTER

MINES BRANCH
JOHN McLEISH, DIRECTOR

Canada. Mines, Bureau of

# BARIUM AND STRONTIUM IN CANADA

BY

Hugh S. Spence



OTTAWA
GOVERNMENT PRINTING BUREAU
1922

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No. 570

## AUTHOR'S PREFACE

The following report has been prepared in order to present in a comprehensive form the available information on barium and strontium minerals in Canada.

A report on the barytes deposits of the Lake Ainslie district, Nova Scotia, was prepared in 1907 by H. S. Poole, and published by the Geological Survey of Canada. This report contained considerable information relating to barytes deposits in Nova Scotia and other parts of Canada, and dealt also with the uses of barytes. The writer is indebted for much of the information concerning the earlier worked Canadian barytes deposits to the above-mentioned report.

For much of the data on the occurrence of barium and strontium minerals in foreign countries; uses, and general technology of barium and strontium; and statistics of the barium industry in the United States, the publications of the United States Geological Survey and of the United States Tariff Commission—listed in the Appendix—have been freely drawn upon.

All the analyses of barytes samples collected in the field were made by E. A. Thompson, of the Mines Branch.



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## CONTENTS

PART I—CHAPTER II—*Concluded*



CHAPTER III

# PART II

## STRONTIUM

### CHAPTER I



### CHAPTER II

## ILLUSTRATIONS

*Photographs*



*Drawings*

# BARIUM AND STRONTIUM IN CANADA

## PART I

## BARIUM

### CHAPTER I

### HISTORY OF BARYTES MINING IN CANADA

The bulk of the barytes produced in Canada, to date, has been derived from the province of Nova Scotia.

The earliest recorded production of barytes in Canada was from deposits at Five Islands (Colchester county), and Brookfield (Hants county), Nova Scotia. These deposits were first worked between 1865 and 1870, and together yielded about 5,000 tons of barytes; but very little mining has been conducted there since 1880.

In 1869, the silver-bearing veins in Thunder Bay district, Ontario, were discovered; and certain of the leads—notably that on McKellar island—proved to carry a large amount of barytes. The McKellar Island deposit was worked for barytes for several years, and appears to have yielded several thousand tons of ore. The last work conducted there was in 1894.

In 1894, development of the extensive deposits on the east side of Lake Ainslie, Cape Breton island, Nova Scotia, was commenced, and this district has, from 1904 to the present time, furnished practically the entire output of Canadian barytes. The total production from this area, to date, may be placed at about 18,000 tons. From 1900 to 1903, mining was conducted at Cap Rouge, North Cheticamp district, about 35 miles north of the Lake Ainslie deposits, and shipments aggregating 2,500 tons were reported.

Scattered deposits of barytes, most of them small, and of only minor importance, have been worked at various times during the past 30 years, in southeastern Ontario, and in Quebec, within a radius of about 100 miles of Ottawa. The total amount of ore secured from these occurrences was small, and few of them attained the status of shippers.

In more recent years, since 1910, attention has been drawn to the existence of large bodies of barytes in northern Ontario. The first deposit to be exploited was situated in Langmuir township, in the Porcupine district, and later, other occurrences were found in the Elk Lake and Matachewan areas. In 1917, a large vein was discovered in Penhorwood township, 150 miles west of Sudbury. The Premier Langmuir mine, near Porcupine, is the only one of these northern Ontario deposits that has been developed, and even this one does not yet figure as a producing mine. Lack of transportation facilities, at the present time, prevents any attempt to develop the Elk Lake and Matachewan deposits.

## MODE OF OCCURRENCE AND CHARACTER OF CANADIAN BARYTES

The Canadian barytes occurrences are predominantly vein deposits. The only notable exception, perhaps, is the Five Islands deposit, in Colchester county, Nova Scotia, where a great deal of the barytes occurs as irregular, pockety masses, in an agglomerate of slate and quartzite, filling depressions between ridges of similar rocks. These irregular masses, however, tend to give way to vein-like bodies as soon as the underlying bed rock is reached. Warren has suggested[1] that the barytes of this deposit has been formed by leaching of the enclosing agglomerate, the deeper veins representing fissure filling from descending waters. This view hardly seems as likely as that the ore has been derived from ascending solutions from the syenite which underlies the Devonian sedimentaries. There does not appear to be any valid reason for conjecturing for the barytes of the Five Islands deposits a different origin from that of other occurrences in Nova Scotia, and even in Canada generally. All the other deposits examined by the writer, in Nova Scotia, Ontario, and Quebec, are of true vein type; and in no case do they present features differing in any way from those normally associated with ordinary fissure veins.

In this connexion, it may be stated that there is considerable difference of opinion regarding the source of the barium of many of the world's important barytes deposits. The deposits in Missouri, Georgia, Kentucky, and Tennessee, in the United States, and those in the United Kingdom, and Germany, yielding the bulk of the world's barytes production, are all associated with sedimentary rocks, chiefly limestones or dolomites, or, as in the case of the American deposits, with clay representing a disintegration product of such rocks. A common genetic relationship may be assumed for all these deposits, but whether the barytes was derived by downward leaching from the enclosing limestone or dolomite, or was deposited from ascending solutions upon fissures in these rocks, is uncertain.

W. A. Tarr[2], in a recent publication, has very thoroughly reviewed the field evidence and literature bearing upon this subject, and concludes that, in the case of the Missouri deposits, the source of the barium is to be sought in "ascending heated waters of igneous origin." A similar origin might be postulated for other barytes deposits occurring in carbonate rocks or their derivatives, although the igneous source of the ascending solutions may not always be apparent.

It does not, however, appear necessary to seek a hydrothermal origin for the barium; that is, to regard it as derived from a deep seated magma, or as having been brought in by solutions from a nearby intrusive. In the case of many deposits in limestones, etc., the barium may equally well have been derived by leaching from underlying crystalline rocks by vadose waters, with the subsequent deposition of barium sulphate upon circulation channels in the overlying sediments. In such case, the barium has possibly gone into solution as the chloride or carbonate, and has been deposited as the sulphate when the waters commingled with others carrying gypsum or other sulphates derived from the sediments.[3]

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[1] Economic Geology, Vol. VI, 1911, pp. 799–807.
[2] Barite Deposits of Missouri, University of Missouri Studies, Vol. III, No. 1, 1918, pp. 75–100.
[3] For a discussion of the conditions necessary for the formation of sulphates in ore deposits, see B. S. Butler Economic Geology, December 1919, p. 581.

H. Everding describes[1] a replacement of Permian limestone by barytes, and concludes that the deposit was formed by (1) alteration of the limestone to gypsum by the action of sulphates; and (2) deposition of barytes by the action of barium chloride solutions on the gypsum.

Tarr's principal objection to ascribing the source of the barium to the limestones and dolomites, in the case of barytes deposits enclosed in such rocks, is the failure to detect in them the presence of barium in appreciable amount. In this he is supported by C. W. Dickson[2], who assigns the source of the barium of a barytes vein in the Pre-Cambrian crystalline limestone, near Kingston, Ontario, (see p. 50) to an igneous rock. In this case, however, there is no conclusive evidence on either side, since no intrusive rocks are known to occur in the immediate vicinity of the deposit; hence it must be assumed either that such rock has been removed by erosion, or, that it is deep seated.

Clarke[3] gives the average content of barium oxide in the igneous rocks of the lithosphere as 0·10 per cent. The barium of these rocks is contained mainly in the feldspars and micas. In contrast to this, the sedimentary rocks were found to carry much less barium; 0·05 per cent barium oxide in the shales examined; 0·05 per cent in the sandstone; and none at all in the limestones. Many spring waters, and also mine waters, have, however, been found to carry barium.

While, on account of the demonstrated higher content in barium of the crystalline rocks, it may appear more reasonable to ascribe the source of the barium of many barytes deposits to such rocks rather than to the sedimentary limestones in which the veins occur, it is assuming too much to preclude the possibility of the sediments having furnished the barium merely on account of their low or negative barium content, as shown by analysis. Unless barium is specially looked for, small traces are very likely to be lost sight of in analysing a limestone. On account of its low solubility ratio, barytes may readily be deposited, under proper conditions, from solutions containing barely perceptible traces of barium—as, for instance, from sea water. Lindgren[4] states that barium is commonly contained in vadose waters in sedimentary rocks.

In the absence of any direct evidence to the contrary, it seems rational to consider that many barytes deposits of vein type have derived their barium content from the rocks in which they occur, whether sedimentary or crystalline. In the case of a vein extending downward through limestone into an underlying rock of crystalline character (examples of such deposits occur in Nova Scotia and southeastern Ontario), the barium may conceivably, have been derived from either or both of the abovementioned rock types.

Delkeskamp[5], in a paper on the wide distribution of barium in the rocks of the earth's crust, and in mineral springs, concludes that "while a thermal origin may preferably be ascribed to many ore deposits, in the case of barytes deposits, the lateral secretion theory is not to be disregarded and has, in some instances, been shown to be undoubtedly the correct one."

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[1] Zeitschrift f. p. Geologie, 1903, pp. 89–106.
[2] School of Mines Quarterly, Vol. 23, pp. 266–270, 1001–2.
[3] Data of Geochemistry, 4th Ed., Bull. No. 695, U.S. Geol. Surv., p. 33. See also, p. 582, ibid.
[4] Mineral Deposits, 1913, pp. 89, 191.
[5] Zeitschrift f. p. Geologie, 1902, pp. 117–126.

It is difficult to conceive of deposition from leached sediments in the case of the northern Ontario barytes veins. These veins represent true fissure fillings, and are found in crystalline rocks (syenite, diabase, and schist) and in one case, in Pre-Cambrian (Huronian) conglomerate. There is no evidence that Palæozoic sediments ever extended over the area in which the barytes deposits are found; instead, it is probable that the region has persisted as a land surface since Pre-Cambrian times. If, therefore, the barytes has been derived from sediments, by leaching, these sediments must have been of Pre-Cambrian age. The character of the veins and of the ore, however, would point rather to deposition from ascending solutions, in the same manner as barytes has been formed as a gangue mineral on many metalliferous veins. The occurrence of metallic sulphides and native silver in the vein in Langmuir township, supports this view.

The Canadian barytes deposits differ radically from those in the United States which yield the bulk of the American production—namely, the Georgia and Missouri occurrences. In these States, the barytes occurs as nodules and irregularly shaped masses, in a residual clay representing a disintegration product of dolomite. The ore is won by pick and shovel in the Missouri district, while in Georgia steam shovels are largely employed. In both cases, mining is a surface operation. In 1918, these two States contributed 118,000 of the 155,000 tons of barytes produced in the United States. Two varieties of crude barytes are recognized in the trade: namely, "hard crystalline," and "soft." The Missouri barytes is of the soft variety, while that of the Cartersville district, in Georgia, is hard crystalline. In Tennessee, both types are found. The soft variety is generally preferred by the grinders on account of its texture and ease of grinding and bleaching.

Canadian barytes, while uniformly of vein type, exhibits differences in physical character (texture, hardness, grain, etc.) in the same way as that of the American deposits. The dissimilarity between the ore from different districts is, in fact, even more pronounced than in the case of the latter. As a general thing, Nova Scotian barytes is soft and opaque, with a coarsely crystalline, platy structure: there is seldom approximation to regular texture, with prominent cleavage. The Five Islands deposit yielded large aggregates of clear, well-formed, tabular barytes crystals in addition to soft, opaque barytes; as a general thing, however, freely crystallized barytes is not common in the Nova Scotian deposits. The colour of this ore is usually cream or grey, to white.

Most of the barytes of the small veins in the Ottawa district is of the compact, opaque type. It differs from the Nova Scotian barytes, in being usually more massive, and is made up of a dense aggregate of thin, platy crystals, arranged in roughly parallel or slightly divergent grouping, at right angles to the vein walls. The barytes has deposited as a crust on both vein walls, and rough banding parallel to the walls is often visible in the ore. There is frequently a distinct parting down the middle of the vein, and wherever free spaces existed, there has been development of "crested" barytes (see Plate XIV). There is a wide variation in the colour of the barytes of these veins, the ore ranging from white through cream and pink to brownish-red. Generally, the colour seems to be dependent on the nature of the enclosing rock; where this is white, crystalline, Archæan limestone, or grey Ordovician limestone, the colour is

usually light; while the veins enclosed in gneiss carry a pink to reddish barytes. In some instances, the veins in Ordovician limestone have their ore darkened by hydrocarbon (anthraxolite). There is close similarity between the ore of practically all the deposits in the area in question, and the barytes is quite distinct in character from that of other Canadian localities. With perhaps a few exceptions, the veins of this district are too narrow to be worked profitably.

A single exception to the above-described prevailing type in this region is that in Lavant township, described on page 53. There, the barytes appears to give way in depth to metallic sulphides, and the vein may properly be considered as a metalliferous deposit, with a barytes gangue. The barytes of this deposit is of hard crystalline type, fine-to medium-grained, and translucent, somewhat resembling that of the northern Ontario occurrences.

The northern Ontario deposits carry a more or less uniform grade of hard crystalline barytes. The texture of the ore varies considerably, however, in the different deposits, and even, also, on one and the same vein. The bulk of the ore is quite coarsely crystalline and massive; there is no development of crested barytes and free crystals are rare. A proportion of the barytes in all of the deposits, however, possesses an exceedingly fine-grained texture, much resembling massive gypsum in appearance. In this fine-grained ground mass, large barytes crystals often occur porphyritically. Most of the ore is white and translucent. The large vein in Yarrow township, Matachewan district, carries ore of an unusual grey to grey-brown shade; this is an inherent coloration, however, and is not due to staining, and the ore yields a good white product when ground. The barytes of the deposit in Lawson township, west of Elk Lake, is rather softer than that of the other northern Ontario occurrences; in addition, it is unusually white and exceedingly pure (see page 39).

The principal mineral impurities present in Canadian barytes are small amounts of sulphides (chalcopyrite, pyrite, sphalerite, and galena), calcite, fluorite, and also sulphates of lime and strontium. Practically all the barytes samples analysed in the Mines Branch laboratory for the purpose of this report showed some strontium sulphate, and about half of them contained calcium sulphate. For the purpose of comparison, the results of analyses of samples taken from the various deposits are given below. The analyses were made in the Mines Branch laboratory by E. A. Thompson, and the material for analysis in each case (except No. 1) was selected to represent, as far as possible, the average ore.

**Analyses of Canadian Barytes**

| Sample No. | Barium sulphate | Strontium sulphate | Calcium sulphate | Calcium carbonate |
|---|---|---|---|---|
| 1 | 71·96 | 2·70 | 14·57 | 9·46 |
| 2 | 96·46 | 0·80 | ........ | 1·78 |
| 3 | 93·42 | 4·10 | 1·40 | ........ |
| 4 | 92·13 | 6·20 | ........ | 1·60 |
| 5 | 95·26 | 4·00 | ........ | ........ |
| 6 | 92·59 | 1·50 | 4·50 | ........ |
| 7 | 92·50 | 1·00 | ........ | 5·00 |
| 8 | 98·03 | 0·70 | 1·20 | ........ |
| 9 | 87·98 | 1·50 | ........ | 8·21 |
| 10 | 89·27 | 4·90 | ........ | 5·36 |
| 11 | 93·51 | 1·00 | ........ | 3·57 |
| 12 | 86·60 | 3·40 | 3·52 | 3·81 |
| 13 | 98·67 | 0·70 | 0·30 | ........ |

No. 1. Range X, lot 7, township of Hull, Que. (Selected material from old workings.)
No. 2. Concession VIII, lot 20, township of Lavant, Ont.
No. 3. Concession VI, lot 12, township of Bathurst, Ont.
No. 4. Concession IV, lot 16, township of Kingston, Ont.
No. 5. Concession IX, lot 20, township of North Burgess, Ont.
No. 6. Range III, lot 12, township of Onslow, Que.
No. 7. Concession IV, lot 11, township of Fitzroy, Ont.
No. 8. Eby or Scott claim, township of Lawson, Ont.
No. 9. Range VI, lot 11, township of Templeton, Que.
No. 10. Concession VIII, lot 5, township of Portland, Ont.
No. 11. Range IV, lot 21, township of Buckingham, Que.
No. 12. Premier Langmuir mine, township of Langmuir, Ont.
No. 13. Ontario Barium Company's claim, township of Yarrow, Ont.

## STATISTICAL

### Production

The following table shows the annual production of barytes in Canada from 1885 to 1920.[1]

| Year | Tons | Value | Year | Tons | Value |
|---|---|---|---|---|---|
| | | $ | | | $ |
| 1885 | 300 | 1,500 | 1903 | 1,163 | 3,931 |
| 1886 | 3,864 | 19,270 | 1904 | 1,382 | 3,702 |
| 1887 | 400 | 2,400 | 1905 | 3,360 | 7,500 |
| 1888 | 1,100 | 3,850 | 1906 | 4,000 | 12,000 |
| 1889 | ........ | ........ | 1907 | 1,344 | 3,000 |
| 1890 | 1,842 | 7,543 | 1908 | 4,312 | 19,021 |
| 1891 | ........ | ........ | 1909 | 179 | 1,120 |
| 1892 | 315 | 1,260 | 1910 | ........ | ........ |
| 1893 | ........ | ........ | 1911 | 50 | 400 |
| 1894 | 1,081 | 2,830 | 1912 | 464 | 5,104 |
| 1895 | ........ | ........ | 1913 | 641 | 6,410 |
| 1896 | 145 | 715 | 1914 | 612 | 6,169 |
| 1897 | 571 | 3,060 | 1915 | 550 | 6,875 |
| 1898 | 1,125 | 5,533 | 1916 | 1,368 | 19,393 |
| 1899 | 720 | 4,402 | 1917 | 3,490 | 54,027 |
| 1900 | 1,337 | 7,605 | 1918 | 580 | 9,145 |
| 1901 | 653 | 3,842 | 1919 | 468 | 8,154 |
| 1902 | 1,096 | 3,957 | 1920 | 751 | 22,983 |

[1] Figures taken from Mines Branch Annual Reports on Mineral Production of Canada, and may include both crude and milled barytes.

It will be noted that the barytes mining industry has been subject to periodic rises and declines, and that there has been no consistent growth shown. Several grinding mills have been operated at different times, three in Nova Scotia, one in Montreal, and one in northern Ontario. Only two of these mills, namely, that of Barytes, Ltd., at Scotsville, Nova Scotia, and that of Premier Langmuir Mines, Ltd., in Langmuir township, northern Ontario, were equipped with concentrating machinery; and the Scotsville mill is the only one where bleaching of the ground barytes has been practised. The sole mill in operation at the time of writing (December 1920) is that of Messrs. Brandram-Henderson, at Halifax, N.S., where Lake Ainslie ore is ground, to supply the Company's paint works.

One reason for the failure to establish a barytes industry in Canada would appear to be insufficient attention to the requirements of the trade; with the result that the ground barytes offered has—either on account of its not being ground fine enough, or because of its being off-colour, or contaminated by mineral impurities—been unable to meet market specifications. The greater hardness of most Canadian barytes, as compared with Missouri ore, is a point that does not appear to have received proper recognition. Whether Canadian barytes can be substituted satisfactorily for the Missouri article, in the domestic ground barytes market, may be considered questionable.

In any attempt to establish a ground barytes industry in Canada, however, closer attention to the grinding of the ore and the sizing of the ground barytes than has, in most cases, heretofore been given, is a prime requisite.

## Exports and Imports

In 1904 and 1905, a considerable proportion of the barytes mined was exported, apparently as crude ore. Since 1909, practically all the ore mined has been ground in domestic mills, and consumed in Canada. The last year in which any quantity of barytes was exported, was 1908, when 175 tons, valued at $13,690, was reported.[1]

Imports of barytes have not been separately shown in the Customs Department classification since 1890, though figures relating to barium peroxide are given. Imports of blanc fixe (artificial sulphate of barium) are joined with those of satin white (a mixture of calcium sulphate and alumina, used in paper-making). Three firms in Canada manufacture hydrogen peroxide from barium peroxide, namely the National Drug and Chemical Company of Canada, Ltd., and Laporte-Irwin, Ltd., both of Montreal, and Henry K. Wampole and Co., Ltd., Perth, Ont. These firms produce blanc fixe as a by-product. The barium peroxide used, is imported. The imports of this material in 1918 were 53 tons, valued at $27,893.

There are no manufacturers of lithopone or other barium chemicals in Canada.

According to Howells Frechette[2], the total annual consumption of barytes by Canadian manufacturers in 1912 was about 3,500 tons. Nearly 3,000 tons of this was reported as imported material. The total number of firms using barytes at this time was 35. A more recent survey of the principal domestic industries using barytes, barium chemicals, and lithopone, has lately been conducted by the Dominion Bureau of Statistics, and the following figures are taken from a return supplied by the above Bureau. It will be noted that while the number of firms using ground barytes has increased between 1912 and 1920, from 35 to 49, the consumption of this material has apparently remained stationary.

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[1] Trade and Navigation. NOTE.—The valuation figure is so excessively high—over $78 per ton—that it seems possible that the figures of quantity (3,509 cwt.) quoted in the above report should read 3,509 tons.

[2] Non-Metallic Minerals Used in the Canadian Manufacturing Industries, Mines Branch Report No. 305, 1914 p. 9.

## Consumption in Canada in 1920 of Ground Barytes, Lithopone and Barium Chemicals[1]

| Trade | Number of firms | Ground barytes | Lithopone | Blanc fixe | Barium carbonate | Barium chloride | Barium peroxide |
|---|---|---|---|---|---|---|---|
| | | pounds | pounds | pounds | pounds | pounds | pounds |
| Paint | 36 | 5,176,200 | 5,808,700 | 116,600 | | | |
| Rubber | 13 | 1,328,000 | 1,065,600 | 30,000 | 6,000 | | |
| Paper | 5 | ........... | ........... | 280,000 | ........... | 550 | |
| Linoleum and oilcloth | 1 | ........... | 1,600,000 | | | | |
| Drugs and Pharmaceuticals | 4 | ........... | ........... | ........... | ........... | ........... | 77,500 |
| Total | 59 | 6,504,200 | 8,474,300 | 426,600 | 6,000 | 550 | 77,500 |

[1]Figures supplied by the Mining, Metallurgical and Chemical Division of the Dominion Bureau of Statistics.

## Prices and Markets

The market for ground barytes on this continent is supplied chiefly from the deposits in Missouri. This is due to the fact that the Missouri ore is softer and better adapted for grinding than that from other known American deposits.

The bulk of the Canadian barytes is of the hard crystalline type, more resembling that of the southern States (Georgia, Kentucky, and Tennessee); and like the latter, is probably more likely to find employment in the lithopone and barium chemical industries. Since no such industries have been established in Canada up to the present time, the immediate outlet for the Canadian ore—more especially Nova Scotian—would appear to be the lithopone and barium chemical plants in the United States. While, possibly, with proper attention to grinding equipment, sizing of the ground product, and elimination of mineral impurities, Canadian barytes might be made to meet trade specifications for the higher grades of ground barytes, it is questionable if this could be done at a profit, and the product made to meet competition from the Missouri material in the domestic market.

In this connexion, the following data on the barytes industry in the United States are of interest. The information is taken from a comprehensive report recently issued by the United States Tariff Commission entitled "Barytes, Barium Chemical and Lithopone Industries." This report is No. 18 of Tariff Information Series, and may be obtained from the Superintendent of Documents, Washington, D.C.

### THE BARYTES AND BARIUM PRODUCTS INDUSTRY IN THE UNITED STATES

Prior to the war, about 65 per cent of the American production of crude barytes came from Missouri, and supplied manufacturers of ground barytes in the Middle West. During the war, the Missouri production doubled, and at the same time the greatest state production shifted to Georgia, in 1916. The producing industry at the present time is localized in two distinct districts: (1), the Middle Western district, represented chiefly by Missouri; and (2), the Southern district, represented chiefly by Georgia, Tennessee, and Kentucky. In the same way there are two distinct markets for crude barytes: (1), the Atlantic coast market (Baltimore to New York); and (2), the Middle Western market (St. Louis and Chicago).

Prior to the war, the American Atlantic coast market for crude barytes was supplied exclusively by imports (chiefly German). These imports represented about 40 per cent of the total domestic consumption of crude barytes, and the material was employed almost wholly in the manufacture of lithopone. In 1914, the price of German crude barytes laid down at eastern United States plants was $5.20 per ton, made up as follows:—

| | |
|---|---|
| Price f.o.b. mine | $1.75 |
| Freight to Rotterdam | 1.20 |
| Ocean freight | 1.75 |
| Price ex ship New York | 4.70 |
| Price at plants on Atlantic coast[1] | 5.20 |

At this time (1914), the market for American crude barytes was confined to the Middle Western manufacturers of ground barytes. With the shutting off of German imports at the outbreak of the war, Eastern lithopone manufacturers sought a domestic supply of crude barytes, and this resulted in the development on a large scale of the Southern deposits (Georgia, Tennessee, and Kentucky). It appears to be questionable whether these deposits can meet competition from German crude barytes in the Atlantic coast market, when normal conditions are restored; and there is agitation by Southern producers for the imposition of a higher duty on imported crude.

Previous to the war, and under the Tariff Act of 1909, imported ground barytes was subject to a duty of $5.25 per ton, consequently, Middle Western ground barytes was able to compete in the Atlantic coast market against German material.

Under the present (1913) Act, however, the import duty on ground barytes is 20 per cent, ad valorem, and it is possible that with normal conditions restored German ground barytes may be able to displace the Middle Western material in the Atlantic coast market. Middle Western producers of ground barytes are, therefore, chiefly interested in an increased tariff on manufactured barytes. Middle Western producers of crude barytes are not so concerned with a tariff on crude ore, as the situation has been improved during the war by the establishment in the Middle West of lithopone plants, which require crude ore as raw material.

It has been estimated that about 50 per cent of the ground barytes manufactured in the Middle West, was, prior to the war, and still is, shipped to Atlantic coast consumers. The Middle West material costs more laid down at Atlantic coast points than Southern ground barytes, owing to the higher freight rate of $1.25 per short ton, but is preferred owing to its greater softness. Southern crude barytes is taken by Atlantic coast consumers principally as raw material for lithopone and barium chemical manufacture.

In the early part of 1920, the market price of crude barytes f.o.b. Missouri shipping points was from $10 to $10.80 per short ton. At the same time, the contract price of Missouri ground barytes f.o.b. St. Louis, in carload lots, was $21.50 per short ton. During the same period, the price of crude Southern barytes f.o.b. Georgian shipping points, was $8.95 per short ton, and the price of the ground material, $18.75 per short ton.

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[1] Includes duty under Act of 1913 and barge or switching charge to plant.

The following table shows the freight rates obtaining in May 1920, both from the Southern and Missouri producing points to the principal Eastern consuming centres:—

### Freight Rates on Crude Barytes per Short Ton

| To | From | | |
|---|---|---|---|
| | Cartersville, Georgia | Sweetwater, Tennessee | St. Louis, Missouri |
| | $ | $ | $ |
| Camden, N.J. | 4 29 | .... | 5 60 |
| Newark, N.J. | 4 73 | 4 82 | 6 00 |
| Grasselli, N.J. | 4 73 | 4 82 | 6 00 |
| Newport, Del. | 4 73 | 4 29 | 5 60 |
| Baltimore, Md. | 3 75 | 3 75 | 5 40 |
| Palmerton, Pa. | 4 73 | 4 82 | 5 60 |
| Chicago, Ill. | 5 54 | 4 46 | 2 10 |
| Philadelphia, Pa. | 4 29 | 4 29 | 5 60 |

From this table, it will be seen that the Southern district has an average advantage in freight charges to the Eastern lithopone plants of $1.25 per short ton. It is this difference that has prevented active competition in the Eastern market between the Southern and Western barytes.

From the above figures and those showing the f.o.b. selling price, the cost of crude Southern barytes laid down at Eastern lithopone plants during the first half of 1920, amounted to $13.40. The price of ground barytes laid down at the same points, and taking the same freight rates, would be $27.20 for the Missouri product, and $23.22 for the Southern product.

To indicate the growth in the barytes industry in the United States, in the period 1914-1919, the following figures are given. It will be noted that the domestic production of crude ore almost quadrupled, and that imports of crude and ground barytes practically ceased.

### Consumption of Barytes in the United States 1914 and 1920

| Year | Sales of domestic barytes | Imports of crude barytes | Imports of ground barytes |
|---|---|---|---|
| | short tons | short tons | short tons |
| 1914 | 52,747 | 29,776 | 4,919 |
| 1919 | 190,000 | 39 | |

The great growth of the barium chemical and lithopone industries, as compared with the ground barytes industry, is shown by the following figures:—

### Crude Barytes Used in the Manufacture of Barium Products in the United States, 1915 and 1919

| Year | Barium chemicals | Lithopone | Ground barytes | Total |
|---|---|---|---|---|
| | short tons | short tons | short tons | short tons |
| 1915 | 10,216 | 44,503 | 53,903 | 108,622 |
| 1919 | 27,696 | 103,968 | 63,051 | 194,715 |

Under the above heading of "Barium chemicals" are comprised blanc fixe, barium carbonate and barium chloride, in the order of production. Before the war, Germany supplied the United States with about two-thirds of her consumption of barium chemicals. The establishment of a barium chemical industry in the United States in 1915, resulted in an importation of 38,000 short tons of barium chemicals in 1914, being changed to a domestic production in 1918, of 92,000 tons.

Prior to the war, the entire American lithopone industry was located along the Atlantic seaboard, and the crude barytes consumed was principally of German origin. In addition to the development of Southern barytes deposits as a domestic supply of crude barytes, when German imports were cut off, the manufacture of lithopone was commenced in the Middle West. As shown above, the production of lithopone in the United States has more than doubled between 1915 and 1919. About 80 per cent of the production in 1919 was derived from Atlantic coast plants. A considerable export trade in lithopone is stated to have developed during 1920.

The present tariff on barytes and barytes products entering the United States, is as follows:—

Baryta, sulphate of, or barytes, including barytes earth:—

| | |
|---|---|
| Unmanufactured | 15 per cent ad valorem |
| Manufactured | 20 per cent ad valorem |
| Baryta, carbonate of, or witherite | Free |
| Lithopone | 15 per cent ad valorem |
| Blanc fixe | 20 per cent ad valorem |

In order to meet foreign competition, American producers of barytes and barium products, formed, in 1919, a protective association known as "The Barium Producers and Manufacturers of the United States." This association has been instrumental in introducing into Congress a new tariff bill which provides for the following import duties on barytes and barium chemicals:—

| | |
|---|---|
| Barytes, crude and manufactured | $10 per ton |
| Barytes or barium sulphate, manufactured | $15 per ton |
| Barium carbonate | $20 per ton |
| All other barium compounds | $20 per ton |

The above tariff bill is at the present time before the Committee of Ways and Means.

With regard to the probable life of the United States barytes deposits, producers and consumers appear to hold different views. In the opinion of the consumers, from two to seven years is the limit for the known deposits; while, on the other hand, producers state that the deposits can supply the domestic demand for an indefinite period.

## Principal Consumers of Barytes in the United States

The following lists give the principal manufacturers of ground barytes, barium chemicals, and lithopone in the United States.[1]

### GROUND BARYTES

Barbour Chemical Works, 707 West Coast Life Building, San Francisco, Calif. (Plant at Oakland, Calif.)

Central Pigment Co., Strand Building, Forty-Seventh Street and Broadway, New York, N.Y. (Plant at Nicholasville, Ky.)

[1] Names taken from U.S. Geol. Surv., Mineral Resources, Part II, 1918.

Cherokee Chemical Co., 109 Hollingsworth Street, Baltimore, Md. (Plant at Kings Creek, S.C.)

J. C. Finck Mineral and Milling Co., 101 Barton St., St. Louis, Mo. (Plant at St. Louis.)

Nulsen, Klein & Krausse, Manufacturing Co., Levee and Sidney Streets, St. Louis, Mo. (Plant at St. Louis and Lynchburg, Va.)

Point Milling and Manufacturing Co., Mineral Point, Mo. (Plant at Mineral Point, Mo.)

Thompson, Weinman & Co., 100 William St., New York, N.Y. (Plant at Cartersville, Ga.)

BARIUM CHEMICALS

American Barium Co., 57 Post Street, San Francisco, Calif. (Plant at South San Francisco.)

Ault & Wiborg Co., Cincinnati, Ohio. (Plant at St. Barnard, Ohio.)

Barbour Chemical Works, 707 American National Bank Building, San Francisco, Calif. (Plant at Melrose, Calif.)

Chicago Copper and Chemical Co., West Jackson Boulevard, Chicago, Ill. (Plant at Blue Island, Ill.)

Clinchfield Products Corporation, 120 Broadway, New York, N.Y. (Plant at Johnson City, Tenn.)

Durex Chemical Co., 320 Fifth Avenue, New York, N.Y. (Plant at Long Island City, N.Y., and Sweetwater, Tenn.)

Grasselli Chemical Co., Cleveland, Ohio. (Plant at Grasselli, N.J.)

Midland Chemical Co., 80 East Jackson Boulevard, Chicago, Ill. (Plant at Argo, Ill.)

Oakland Chemical Co., 10 Astor Place, New York, N.Y. (Plant at New York.)

Rollin Chemical Co., Charleston, W. Va. (Plant at Charleston.)

LITHOPONE

Butterworth-Judson Corporation, 61 Broadway, New York, N.Y. (Plant at Newark, N.J.)

Chemical Pigments Corporation, 825 Stock Exchange Building, Philadelphia, Pa. (Plant at St. Helena, Md.)

E. I. Du Pont de Nemours & Co., Wilmington, Del. (Plant at Camden and Newark, N.J., and Philadelphia, Pa.)

Grasselli Chemical Co., Cleveland, Ohio. (Plant at Grasselli, N.J.)

Keels Pigment & Chemical Co., Newport, Del. (Plant at Newport.)

Midland Chemical Co., 80 East Jackson Boulevard, Chicago, Ill. (Plant at Argo, Ill.)

Mineral Refining & Chemical Corporation, Carondelet Station, St. Louis, Mo. (Plant at St. Louis.)

New Jersey Zinc Co., 55 Wall St., New York, N.Y. (Plant at Palmerton, Pa.)

Sherwin Williams Co., 601 Canal Road, Cleveland, Ohio. (Plant at Kensington, Ill.)

## BARYTES IN OTHER COUNTRIES

The report quoted above gives figures of production in several European countries.

The United Kingdom, in 1918, ranked third as a producer of crude barytes, the output being 63,000 tons. Normal requirements in the United Kingdom for crude barytes amount to about 100,000 tons, and prior to the war 60 per cent of this quantity was imported from Germany. English producers now supply a product equal in quality to that previously obtained from Germany. About 70 per cent of the barytes obtained in the United Kingdom enters into lithopone and paints, the remainder going to the paper, rubber, and linoleum trades. The barium chemical industry uses chiefly witherite (barium carbonate), of which there are large domestic deposits.

According to figures of production and imports, the consumption of barytes in the United Kingdom appears to have fallen off considerably between 1913 and 1918. In 1913, the production and imports totalled nearly 111,000 short tons, while in 1918, the figure was 74,000 tons. In 1917, the average reported value of domestic crude barytes was $9.37. At the end of 1919, ground barytes was quoted at from $30 to $60 per short ton, f.o.b. works.

Italy, in 1918, produced 15,000 tons of crude barytes, and Spain 4,000 tons. The French production in 1913 was about 12,000 tons, and Belgium produced about the same quantity. German exports, in 1913, totalled 174,000 short tons of crude ore.

# CHAPTER II

## BARYTES MINES AND OCCURRENCES

### BRITISH COLUMBIA

#### GOLDEN MINING DIVISION

Attention has lately been directed to occurrences of barytes near Golden. The district was not visited by the writer, but the following particulars relating to the deposits have been secured from various sources.

In the Annual Report of the Minister of Mines of the province for 1920, page 109, the following note appears:—

> Captain Armstrong is also interested in the Giant mine, near Spillimacheen, where there is a large deposit of barytes and low grade lead ore. It is reported that Eastern capitalists have taken an option on the property and intend to mine the barytes on a large scale.

Writing under date of October 6, 1921, G. G. Ommanney, investigation engineer for the Canadian Pacific railway, furnishes the following information regarding barytes occurrences in this district:—

Barytes occurs on the Grant-Victory[1] claim, 7 miles northwest of Spillimacheen station, on the Kootenay Central railway. A very large tonnage of barytes undoubtedly is available in this deposit, and it is claimed that nearly 500,000 tons of ore has been actually measured up. A much larger amount is probably present, but no attempt has been made to estimate the total quantity available. Analyses of the ore have shown a barium sulphate content ranging from 68 to 95 per cent, with from 3 to 27 per cent silica; selected samples proved to run as high as 98·75 barium sulphate.[2]

Barytes also occurs on the Penrose Wolf claims, situated 5½ miles south of Parsons station, on the same railway.

The barytes occurs at the contact of slates with limestone, and it is stated that the ore contains considerable amounts of sulphides. Some mining was formerly conducted here for zinc.

It is understood that a Calgary syndicate now controls the above claims, and proposes to utilize the barytes in the manufacture of barium chemicals and lithopone.

In a communication to the writer, dated November 23, 1921, A. G. Langley, resident engineer, Revelstoke, B.C., says regarding barytes possibilities in the Golden-Windermere district:—

> Probably the largest and most important deposit from an economic view, is at the Giant mine, on the Spillimacheen river. Here, there is a wide zone of barytes occurring along the contact of limestone and slate. In places, the barytes is impregnated with galena and constitutes considerable bodies of low grade lead ore. The Penrose-Wolf claims are probably in the same zone of contact, which can be traced for a number of miles along the easterly flank of the ridge bordering the west side of the Columbia river.

---

[1] Presumably the same as the "Giant" mine, referred to above.
[2] See also Report of Minister of Mines for British Columbia, 1898, p. 1044; 1909, p. 98.

From personal observation in the field, I would say that barytes is of common occurrence in the Golden-Windermere divisions, and if the prospector had attached any importance to its discovery there would be a greater number of known deposits.

Barytes occurs associated with copper ores at the Bunyan, situated seven miles from Invermere. Here the country rock is schist, and the barytes occurs in lens-like inclusions and stringers.[1]

At the Mineral King, near the confluence of Jumbo and Toby creeks, barytes occurs as a gangue mineral to lead-zinc ores.

At the Tatler group, near the head of the south fork of Horse Thief creek, there are strong indications of barytes, but this location is about 40 miles from the railway.

## NOVA SCOTIA

## Inverness County, Cape Breton Island

### LAKE AINSLIE DISTRICT

Mining of barytes in the Lake Ainslie district, Inverness county, commenced in 1894, when Messrs. Henderson and Potts, of Halifax, opened up a deposit near Trout River, and shipped ore to Halifax, for grinding. This deposit has been worked in more recent years by Messrs. Brandram-Henderson, paint manufacturers, of Halifax, who operate a barytes grinding mill in connexion with their paint works. About 1900, the Eastern Milling Company undertook development of the deposits at East Lake Ainslie, crude ore being shipped to Dartmouth, N.S., for grinding and bleaching. The Dartmouth mill only ran for a couple of years, the holdings of the above Company being then taken over by the Ainslie Mining and Railway Company, who shipped ore to Montreal for grinding. This concern was superseded during 1907–08 by the Barium Production Company, who shipped 6,000 tons of crude ore from the East Lake Ainslie properties. Later, in 1912, a mill was erected at Scotsville by Barytes Ltd., who have mined ore from several of the adjacent properties, and have produced a small amount of refined barytes. For many years past, the Lake Ainslie district has produced practically all the barytes mined in Canada.

The Lake Ainslie barytes deposits consist of a well-defined vein system traversing the high ridge which follows the east shore of the lake. The general trend of the veins is northeast to east, or oblique to the course of the ridge, and the dip south. According to Fletcher[2] and Poole[3], this ridge is composed largely of grey to reddish felsite, of Pre-Cambrian age, and is capped locally by a relatively thin cover of Carboniferous grit or sandstone. Poole[4] says:—

> The barytes-bearing series of rocks are more widespread than appears on the surface, for, not only are the Pre-Cambrian deeply covered in places by drift, which retards prospecting, but they are evidently overlain along the hill flanks by rocks of later deposition. Beds of Lower Carboniferous near the contact have been proved to be, in places, quite shallow. The surface drift is of variable thickness, and bore holes have proved it to be, in places, as much as forty feet. It forms the eastern shore of the lake, except where rock occasionally protrudes through it. The holes bored for oil along the lake side passed through a great thickness of bedded deposits, indicating a continuation of the steep front to the older rocks underlying them. This view also applies to the shelf of felsite which carries with it barytes veins at a level nearer that of the lake. The shelf appears to present a steep front to the submerged north, and from its edge the covering of Carboniferous measures has been eroded, exposing the shoulder and its veins, whence doubtless came the loose, overlying boulders.

[1] See also Report of Minister of Mines for British Columbia, 1915, p. 100; 1920, p. 112.
[2] H. Fletcher, Geol. Surv. Can., Rep. Prog., 1882–84, Part H; Map Sheet No. 13, Island of Cape Breton, 1884.
[3] H. S. Poole, Barytes deposits of Lake Ainslie and North Cheticamp, N.S., Geol. Surv. Can., No. 953, 1907.
[4] Loc. cit., p. 25.

From the foregoing, it would appear that the barytes veins are to be regarded as of Pre-Carboniferous age. They possess marked regularity in the matter of width, both along the strike and in depth. The deepest workings, at depths of 110 and 125 feet, disclosed ore-bodies of 18 feet and 14 feet, respectively. The principal impurities in the ore are calcite and fluorite, but the amount of these minerals present, varies greatly in the different veins. On the McMillan property, analyses of four samples taken at various depths—to 100 feet, showed from 10 to 23 per cent of calcium fluoride, and an average of 12 per cent of calcium carbonate. Samples from other veins, however, yielded less than 1 per cent of calcium fluoride, and 3 per cent of calcium carbonate. Fluorite, of a pale green shade, is a very conspicuous mineral in the vein matter on the Johnston property, near Trout River, often completely filling the interstices in drusy barytes, and forming 30–40 per cent of the mass. While certain of the veins, notably that on the Peter Campbell property, near Scotsville, yield a good white barytes, the majority carry ore exhibiting an inherent pinkish or greyish shade; this coloration cannot be removed by bleaching, and the bulk of Lake Ainslie barytes cannot be classed as of first quality. Barytes Ltd. report that attempts to bleach off-colour ore from various Lake Ainslie properties in their mill at Scotsville were unsuccessful, the acid tanks being finally discarded.

All the Lake Ainslie barytes deposits are situated within fairly easy reach of either water or rail transportation. The maximum distance from the lake shore of any of the properties does not exceed one mile, and a great deal of the ore raised has been taken across the lake by scow to Strathlorne station, on the Inverness railway. A good road also passes close to the deposits and enables ore to be hauled 12–15 miles to Whycocomagh, on Bras d'Or lake, whence shipment may be made by schooner.

The Lake Ainslie barytes deposits may be conveniently considered as three groups of properties, distant about three miles from each other, in a general north and south direction. (See Fig. 1.) Proceeding north, along the east side of the lake, these are:—

1. Johnston property.
2. East Lake Ainslie—McMillan, McDougall, and T. E. Campbell properties.
3. Scotsville—Peter Campbell, Thomas Campbell, and McKinnon properties.

It is possible that other barytes veins occur between these groups, but are concealed beneath the cover of Carboniferous rocks which locally overlie the Pre-Cambrian felsites.

The mineral rights were formerly held by the owners of the soil, and mining operations were conducted under lease and royalty. In 1920, however, by Act of the Provincial Legislature, all minerals in the province, with the exception of gypsum, limestone, and building materials, reverted to the Crown.

### (1) *Johnston Property.*

The barytes veins on this property were the first in the Lake Ainslie district to be worked, mining operations having been commenced about 1894, by Messrs. Henderson and Potts, of Halifax. In more recent years, his property has yielded the barytes employed by the Brandram-Henderson

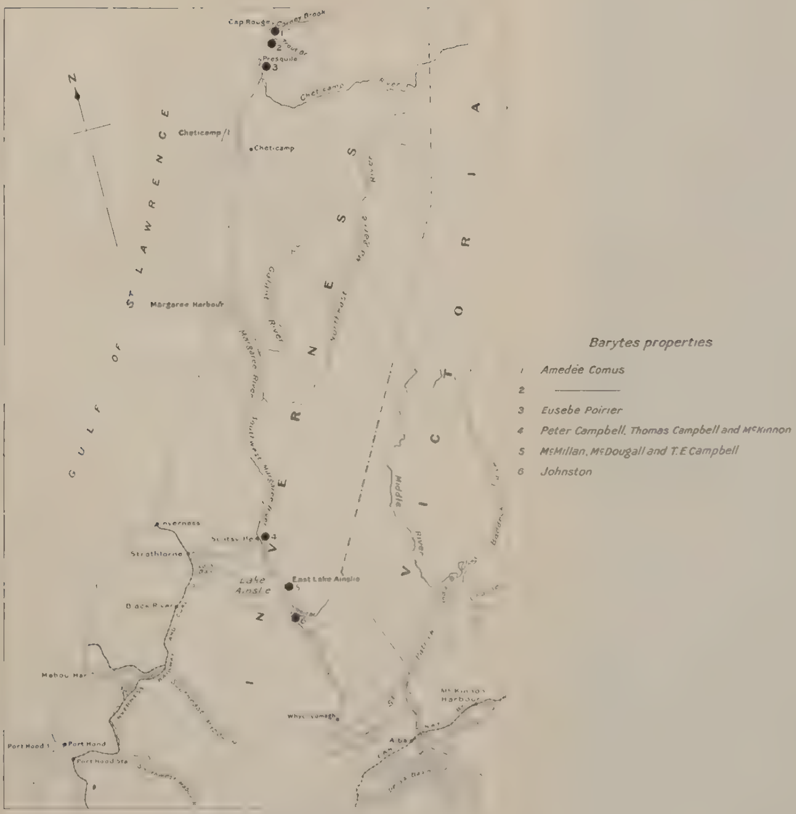


Fig. 1.—Sketch map of Lake Ainslie district, Cape Breton, N.S., showing location of barytes deposits. Scale: 16 miles to 1 inch.

32158—To face page 24

paint works, the crude ore being hauled 12 miles to Whycocomagh, on Bras d'Or lake, from which place it is shipped by schooner to the Company's grinding plant at Halifax. Between 500 and 1,000 tons of ore have been mined annually on this property for some years past.

The mine lies about two miles south of East Lake Ainslie, and a few hundred yards from the lake shore and the main road from Whycocomagh to Scotsville. The workings are situated on the flank of the rising ground, and consist entirely of shallow open pits excavated along the leads. The veins, of which at least three have been partly exploited,[1] strike almost due east, and dip steeply to the north, or into the hill; they are enclosed in a reddish-brown felsite. A dike of trap rock is supposed to cut off the leads eastward, and beyond this the Pre-Cambrian rocks are concealed beneath Carboniferous grits. To the west, also, Carboniferous sediments overlie any further extension of the veins.

The main lead, which possesses a width of 8 to 10 feet, was formerly worked by means of two drifts—an upper and a lower—carried a distance of about 200 feet. At this point, a cross lead from the north is stated to have been encountered, which carried from 9 to 20 feet of ore for a distance of 125 feet. These old workings are now abandoned, and have largely fallen in.

While a small amount of white barytes may be secured by careful hand picking, the bulk of the ore from this property is off-colour. In addition, the vein-matter often carries considerable quantities of pale green fluorite and calcite. The former mineral is especially conspicuous, and frequently occurs partly or wholly filling the space between crystals in drusy barytes.

No mining machinery of any kind is employed, extraction of the ore being by means of open cuts and short drifts. There are no mine buildings on the property.

*Mill*

The grinding mill of Messrs. Brandram-Henderson, at Halifax, has a capacity of 5 tons of ground barytes per diem. It is equipped with a jaw breaker, Sturtevant rotary crusher, and four sets of buhrstones. The product of the first stones splits to the second and third sets, and the products from these form the feed for the fourth set. No screening or air or water separation is practised.

### (2) *East Lake Ainslie: McMillan, McDougall, and T. E. Campbell Properties*

This forms one of the group of properties originally opened up in 1903 by the Eastern Milling Company, of Halifax, and later developed by the Barium Production Company and the Ainslie Mining Company. Practically no mining has taken place on any of the East Lake Ainslie properties since 1908.

The three properties comprising the East Lake Ainslie group adjoin one another, and are situated on the crest and northwest side of Burnt hill—a steep eminence conspicuous for its barren and burnt appearance. The McMillan property is situated near the top of this hill, the vein crossing onto the McDougall property about half way down the slope, while the

[1] H. S. Poole, Barytes Deposits of Lake Ainslie, Geol. Surv. Can., No. 953, 1907, p. 20.

lowest workings, near the foot of the hill, are on the T. E. Campbell property. This group of properties has been the most actively exploited in the Lake Ainslie district, and has probably yielded more barytes than any of the others. It is estimated that between 7,000 and 8,000 tons of barytes have been shipped from here, and that another 2,000 tons of mixed ore are contained in the dumps. The deposit worked consists of one vein, which has been traced under a light cover of drift from the base of the hill to the summit, a distance of 550 feet. This vein has a northwesterly strike, and dips about 60° southwest, cutting the hill obliquely to its longer axis. All the workings are confined to the northwest side of the hill.

*McMillan property.*—The initial operations on the East Lake Ainslie deposit took place on the McMillan property, near the top of the hill. Here, an open cut, 50 feet long, 16 feet wide, and 15 feet deep, was opened on 16 feet of barytes. Later, a shaft was sunk at one end of this cut, and reached a depth of 125 feet. At the 50-foot level in this shaft, a drift was run 50 feet to the west along the vein; at the 125-foot level, drifts were carried 150 feet to the west and 40 feet to the east. The vein is stated to have averaged 16 feet between walls, with a central parting; and the shaft has been sunk on the foot-wall portion of the lead, leaving the hanging-wall portion in place. In some sections of the stopes, however, the entire vein width has been mined. The country rock throughout the workings is a rather loose, reddish-brown felsite, hence it was found necessary to timber the shaft throughout.

Plate III shows a general view of Burnt hill and the mine workings. Ore was shot down the hill from a pocket at the upper workings to a second pocket at the foot of the hill, whence it was trammed to a wharf on the lake, a distance of about 1,000 yards, and taken by scow across the lake to Strathlorne station on the Inverness railway. A skipway was partially completed when mining operations were suspended, in 1908. With the exception of the shaft house, all the mine buildings and machinery were located at the foot of the hill, air for the hoist and drills being piped from this point to the upper workings.

The following analyses of samples taken at various points in the workings are taken from a report on the property put at the writer's disposal by Mr. H. H. Harrison, secretary of Barytes, Ltd., the last Company to operate the deposit.:—

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Silica | 1·07 | 0·87 | 1·02 | 0·68 |
| Oxide of iron and alumina | 1·54 | 0·14 | 1·41 | 1·32 |
| Calcium carbonate | 12·12 | 12·49 | 12·35 | 12·49 |
| Calcium fluoride | 23·05 | 11·14 | 15·27 | 10·14 |
| Barium sulphate | 62·14 | 75·24 | 69·78 | 75·23 |

1. Hanging-wall vein, face of drift on 125-foot level, 100 feet west of shaft.
2. Foot-wall vein, at bottom of shaft.
3. Hanging-wall vein, 75-foot level, at shaft.
4. Foot-wall vein, 50-foot level, at shaft.

The above figures show a practically uniform content of calcium carbonate, but a considerably greater percentage of fluorite in the samples taken on the hanging-wall vein. The colour of all the samples is stated to have been good. Attempts were made at the Company's mill at Scotsville to improve the grade of this ore by concentration—using hydraulic classifiers and Wilfley tables. The process appears to have removed much of the calcite, but not to have succeeded in eliminating the fluorite.

*McDougall property.*—On this property are situated the middle workings, which lie about halfway up the slope of Burnt hill. The vein has been worked here both by an adit and by shaft. These workings, having caved in, have been inaccessible for a number of years. The vein is apparently the same as that worked on the McMillan and T. E. Campbell properties, at the top and base of the hill, respectively.

A sample of the barytes from these workings, taken from the ore dump, is stated to have been of fairly good colour, and to have yielded:—

| | |
|---|---|
| Silica | 0·34 |
| Oxide of iron and alumina | 0·47 |
| Calcium carbonate | 10·71 |
| Calcium fluoride | 1·28 |
| Barium sulphate | 87·14 |

*T. E. Campbell property.*—On this property lie the lower workings, which consist solely of an adit, carried 450 feet into the base of Burnt hill. The vein, at the entrance, measures 14 feet between walls, narrowing to about 12 feet at 200 feet in, and to 6 feet at the face of the drift. This point is 175 feet below the surface. A small stope, put down at the entrance to the tunnel, is stated to have shown 16 feet of ore to a further depth of 20 feet.

A sample taken from the outcrop above the tunnel is stated to have yielded:—

| | |
|---|---|
| Silica | 0·28 |
| Oxide of iron and alumina | 0·34 |
| Calcium carbonate | 2·95 |
| Calcium fluoride | None |
| Barium sulphate | 96·33 |

While of high barium content, the sample was rendered off-colour by the presence of (probably) hydrocarbon; the coloration due to this substance cannot be removed by bleaching with acid, consequently the barytes cannot be made to yield a white product by ordinary means.

(3) *Scotsville: Peter Campbell, Thomas Campbell, and McKinnon Properties.*

This is the most northerly of the three groups of barytes properties in the Lake Ainslie district, and lies at the head of the northeast arm of the lake. Mining commenced here in 1905, and continued till 1915; since that time, all the properties have lain idle. The operators were Barytes, Ltd., of Halifax.

The estimated quantity of barytes shipped from this group of properties is 5,000 tons, over 3,000 tons of which was crude ore.

The widespread occurrence of float barytes along the ridge bordering the east side of Lake Ainslie, would indicate the probable existence of other veins than those already discovered.

The leads appear to be true fissure veins, and locally exhibit a decidedly brecciated structure—particularly on the foot-wall. The country rock is a greenish to reddish-brown felsite, which, being rather loose, necessitates timbering of all mine workings, but permits of natural drainage, and obviates the necessity of pumping.

There is an abundance of hardwood on the Scotsville properties. Coal can be readily and cheaply produced from the nearby Inverness collieries. The deposits, as well as those at East Lake Ainslie, are thus favourably situated for the establishment of a barium chemical works.

Barytes, Ltd., in 1912, built and equipped a mill about one mile from the mine, close to the lake shore. This mill, a two-story wooden building (Plate I), was erected in 1911, and a considerable tonnage of white barytes was ground for market. The mill system was remodelled in 1914 to treat off-colour ore along the lines indicated in Fig. 2, but the operations of the Company were suspended before any material output was attained. The mill system, as outlined in Fig. 2, underwent considerable modifications at various times, and the acid tanks were finally discarded, after it was found that the bulk of the Lake Ainslie ore did not respond to bleaching treatment. The mill was designed to produce one ton of refined barytes per hour. Power was furnished by one 100 h.p. engine, supplied by two 60 h.p. horizontal boilers. Shipment of crude ore and refined barytes was made from a wharf near the mill by scow to Strathlorne station, on the Inverness railway.

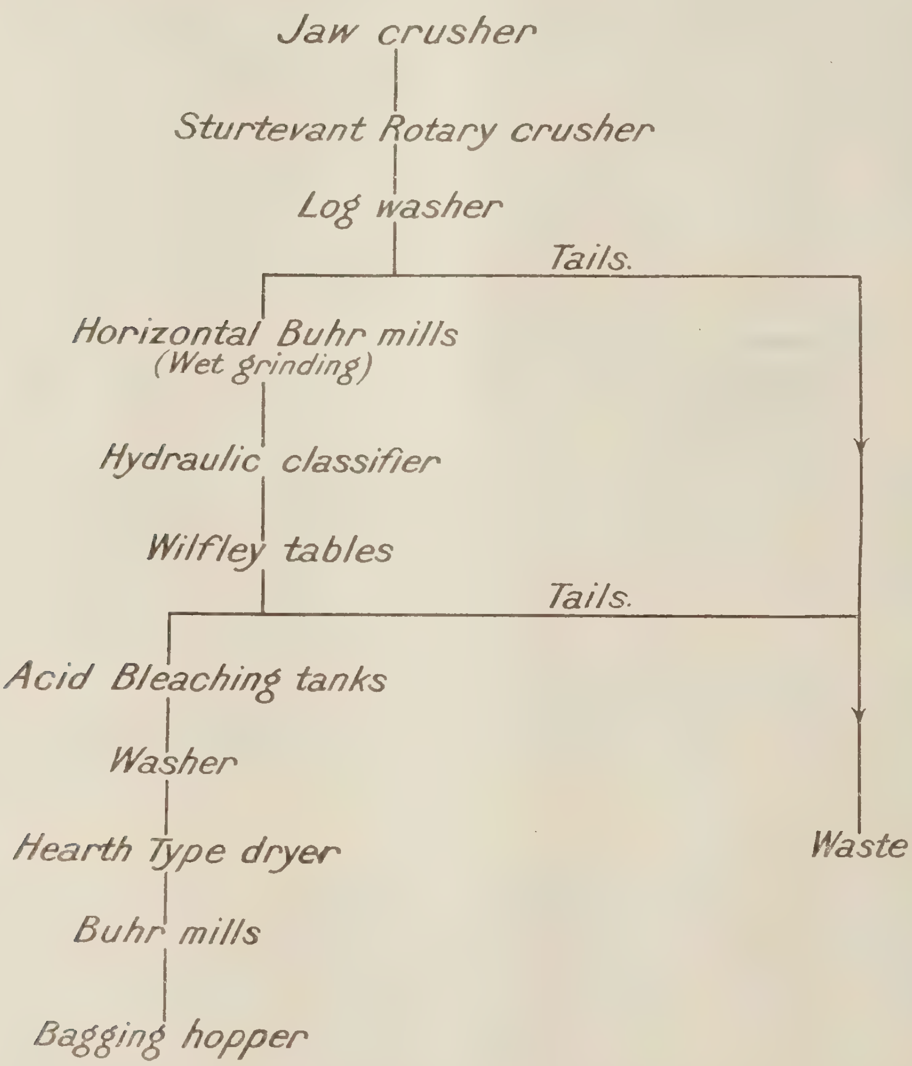


Fig. 2.—Flow sheet of mill of Barytes, Ltd., at Scotsvilie, Cape Breton, N.S.

*Peter Campbell property.*—This property lies on the crest of a ridge rising 750 feet above Lake Ainslie, and is one mile from the mill and the loading wharf on the lake. Only one vein has been worked, first by an open cut, and later by an 8×12–foot shaft. The shaft was sunk on an incline of about 40° south, following the dip of the vein, and reached a depth of 110 feet, measured on the dip. The ground being loose, it was

found necessary to timber the shaft to the bottom. Levels have been run at 80 feet and 110 feet. The 80-foot level has been carried 80 feet east, and 60 feet west of the shaft; and the 110-foot level, 50 feet east, and 20 feet west. The vein at the shaft measured 11 feet between walls at the 80-foot level, and 18 feet at the 110-foot level. Ten feet east of the shaft on the 110-foot level, a raise was put through to the 80-foot level. Ore was extracted by underhand stoping on the 80-foot level, and shot down the raise; hoisting being conducted from the 110-foot level. Practically all the ore above the 110-foot level, the entire length of the drift, has been stoped out, so that any reserves lie below 110 feet, or along extensions of the vein east and west of the points reached in the drifts. According to the last operators, the vein appears to pinch in depth, and is regarded as having been practically worked out.

The shaft is two compartment and is equipped for a double skip way. During the earlier operations, hoisting was by means of a whim, but later a steam hoist was installed. Drilling was performed by hand. All the ore raised was hauled either to the mill or loading wharf at the lake.

Samples of the ore taken at the face of the east and west drifts, respectively, on the 80-foot level, yielded:—

| | East drift | West drift |
|---|---|---|
| Silica | 0·31 | 0·34 |
| Oxide of iron and alumina | 0·69 | 0·44 |
| Calcium carbonate | 3·46 | 5·46 |
| Calcium fluoride | None | None |
| Barium sulphate | 95·43 | 93·67 |

The ore from this vein was of very good colour, and of uniformly high barium content, and was regarded as the best barytes produced in the Lake Ainslie district. A sample of the ground and washed product from the bins at the Company's mill yielded:—

| | |
|---|---|
| Silica | 0·21 |
| Oxide of iron and alumina | 0·34 |
| Calcium carbonate | 3·28 |
| Calcium fluoride | None |
| Barium sulphate | 96·06 |

*Thomas Campbell property.*—This adjoins the preceding one to the south, and has been worked in only a small way. Most of the work done consisted in trenching and stripping. These operations disclosed a body of barytes 4 to 6 feet wide, striking at approximately right angles to the vein on the Peter Campbell property. A pit, 35 feet deep, was sunk on the most promising outcrop, the ore from this opening being of very good colour and high in barium. A sample from the pit yielded:—

| | |
|---|---|
| Silica | 0·24 |
| Oxide of iron and alumina | 0·33 |
| Calcium carbonate | 3·35 |
| Calcium fluoride | None |
| Barium sulphate | 96·00 |

*McKinnon property.*—This lies about 1,500 yards south of the workings on the Peter Campbell property, and has had very little work done upon it. No ore has been taken out, and operations have been confined to stripping the vein. The vein, as exposed in the various small pits, measures from 2 to 4 feet, and has a strike roughly parallel to that on the

Peter Campbell property. The ore is of good colour, and a sample had the following composition:—

| | |
|---|---|
| Silica | 0·23 |
| Oxide of iron and alumina | 0·31 |
| Calcium carbonate | 3·73 |
| Calcium fluoride | None |
| Barium sulphate | 96·64 |

NORTH CHETICAMP

Barytes occurs in the North Cheticamp district, between Cap Rouge and Presqu'île, (see Fig. 1), the known veins being exposed in the schists bordering the shore line. Attempts to mine these deposits were commenced in 1900, and about 2,500 tons of ore is reported to have been extracted and shipped. No mining has taken place in this district for a number of years past. The district was not visited by the writer. The following notes on the deposits are abstracted from H. S. Poole's report.[1]

The veins occur in schists of Pre-Cambrian age, and carry, besides barytes, quartz, calcite, and fluorite. The general course of the veins is north and south and the dip usually vertical. Copper ore, also, was formerly mined in a small way in this district, the copper-bearing veins carrying a considerable amount of barytes as gangue.

On the property of Amedée Comus, at Corney brook[2], a vein of barytes has been traced, and partly opened up for 100 feet. This vein varies in width from 1 to 4 feet, and in one place, swells to 8 feet. Other parallel veins have been observed below high water mark at the same locality. Nearly 1,000 tons of barytes is stated to have been shipped from this deposit.

A second vein has been uncovered on the west side of Trout brook, one mile farther south, where a small lense of barytes is exposed close to the shore road, near the mouth of the brook.

A third vein has been worked on the land of Eusébe Poirier, near Presqu'île, about 1½ mile south of the foregoing, the workings being situated 500 yards from the shore, and at an elevation of 350 feet above sea-level. A drift was run along the lead for 120 feet, the width between walls being 3 to 6 feet. Other openings on the hillside showed that the lead persisted at least a like distance farther to the south. About 200 yards west of these workings, several smaller openings, near the old road, have yielded a small tonnage of barytes. It is estimated that from 750 to 1,000 tons of barytes has been shipped from the Presqu'île deposits.

## Colchester County

FIVE ISLANDS

*Eureka, Bass River, or Duncan Mine.*—This property, which was opened many years ago (about 1866), was originally known as the Eureka mine; it is now more generally referred to as the Duncan mine. This deposit and the one near Brookfield, south of Truro, in Hants county, were the earliest barytes deposits operated in Nova Scotia, if not in Canada. With the exception of about 300 tons secured during development work in 1908, no production has taken place here since 1876. The following

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[1] Barytes Deposits of Lake Ainslie and North Cheticamp, N.S., Geol. Surv., Can., No. 953, 1907, pp. 26–32.
[2] For the approximate relative locations of these properties and for the geology of the district, see Geol. Surv., Can., Map Sheet No. 6, province of Nova Scotia; also, Report of Progress, 1882–84, Part H, pp. 21, 45, 95.

information regarding the deposit and mining operations has been compiled from Geological Survey Reports[1] and from a report made for the owners by Professor C. H. Warren, of the Massachusetts Institute of Technology, and kindly placed at the writer's disposal by W. A. and J. C. Soley, 444 Harrison Avenue, Boston, Mass., the present owners. (See also Economic Geology, Vol. VI, 1911, pp. 799-800).

The deposit lies about 2 miles north of the village of Five Islands, on the north shore of Minas basin. Shipment of ore can be made by boat. All the barytes shipped from the property was crude ore, and most of it went to the United States. Shipments were also made to the paint works of the Dolphin Manufacturing Company, St. Catharines, Ont.

The initial work on the deposit was carried out by Mr. Sewell, of Bath, Maine, and from 1866 to 1876, about 3,000 tons of barytes are reported to have been extracted and shipped. Beyond some work of a prospecting nature in 1907, no further mining appears to have been conducted since 1876.

The barytes occurs chiefly in the form of irregular masses and impersistent veinlets, in Devonian slates and limestones, in contact with red syenite.[2] The dip of the slates is uniformly steep, and in the vicinity of the barytes deposits is almost vertical. The barytes veins occur in the steep cliffs forming the banks of Bass river. The altitude immediately above the main mine workings is 300 feet above river level. The rocks have been much disturbed, and considerable local faulting has taken place. From the main cliffs, lying back from the river, prominent ledges extend, and between these ledges are deep depressions filled with rock debris, the fragments of which are firmly cemented by carbonate of lime, the whole thus forming an agglomerate. It is in this agglomerate that the barytes chiefly occurs, the ore-bodies usually lying in the form of irregular, pockety masses. These masses often extend down through the agglomerate into the underlying slate, and in the latter rock take on more the nature of regular veins. The width of such masses may be as much as 6 feet, and, in some cases, two or more have joined to form an ore-body 10 to 12 feet wide. A large number of leads have been uncovered and worked in the slopes on both sides of Bass river.

Professor Warren suggests that the barytes bodies have been formed by leaching of the enclosing rock (agglomerate), part of the barytes having been deposited in the agglomerate itself and part in fissures in the underlying slates. Filling of the fissures in the slates proceeded, doubtless, also from leaching of the slates themselves.

None of the workings extend below the level of the river, and consequently it is not known whether the barytes bodies persist in depth. However, one large ore-mass exposed in the lowest workings had a width of about 18 feet at almost river level, so that it appears reasonable to anticipate a considerably greater vertical extension of the lead.

The barytes is uniformly very coarsely crystalline, possesses a platy structure, and is often drusy, the cavities being lined with well-formed tabular crystals. Crystallized calcite, also, is commonly associated with it, and often coats the barytes. Small amounts of pyrite, chalcopyrite,

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[1] Geol. Surv. Can., Report of Progress, 1882-84, Part I, p. 23; Mineral Resources Bulletin, No. 963, 1907, p. 15

[2] See Geol. Surv., Can., Map No. 76, Economy River Sheet, 1905.

and specular iron, occur locally. The colour of the ore is predominantly white, but the outer material of the veins and masses is commonly stained pink or reddish by iron oxide. An analysis of a sample of barytes taken from the stock pile, made by H. J. Williams, Boston, yielded:—

| | |
|---|---|
| Silica | 0·95 |
| Iron and alumina | 0·09 |
| Lime | 0·02 |
| Magnesia | 0·22 |
| Barium sulphate | 98·54 |
| Loss on ignition | 0·18 |

A survey of the old mine workings in 1906 indicates that the main ore-bodies occurred in a zone about 70 feet wide, and trending northwest. (See Fig. 3). Most of the ore encountered in these workings has been removed. In 1907, the present owners undertook a considerable amount of development work, with a view to proving up new ore-bodies. The new underground workings are indicated on the plan, Fig. 3. In explanation of this plan, Professor Warren reports as follows:—

Tunnel A cuts a few stringers, but not the main veins. The new (1907) workings are shown on the plan in full lines. Entering B, a vein of barytes is encountered at 65 feet, and is well exposed at A. The vein is 4 feet wide here, and also shows up in the drift C, being 15 inches wide at the point marked b. This may be a new vein, but since it lies so nearly in line with the large mass exposed 20 feet above, it is more likely to be an extension of the latter. Near the end of the drift B, at c, a narrow vein, one foot wide, is exposed, and is again seen in the branch working at d. There is evidently an extension of the same vein met with in the drifts E and F, 30 feet above.

A 10-foot raise has been put up from B into the upper drift E, and in the latter, several narrow veins have been encountered. The end of drift E connects with the old workings above. At the point marked g, a 6-foot vein of barytes is exposed, which narrows to 3 feet about 20 feet to the north.

The old stopes were carried to a height of at least 60 feet above the river, which would give about 40 feet head room in the workings. The veins appear to have no uniform direction, and are most irregular in their width.

The operations in 1907 disclosed a strong vein of barytes about 500 feet south of the main tunnel. This vein measures 19 feet, but carries numerous included fragments of slate; it strikes northeast, and has been uncovered for a distance of 40 feet. Stripping indicates that this lead is an extension of an outcrop some distance to the southwest, and which appears to be part of one of the largest ore-bodies as yet encountered on the property.

Barytes veins are also exposed on property controlled by the same owners on East river, about two miles northeast of the Bass River deposit. Beyond some prospecting, no work has been conducted at this point.

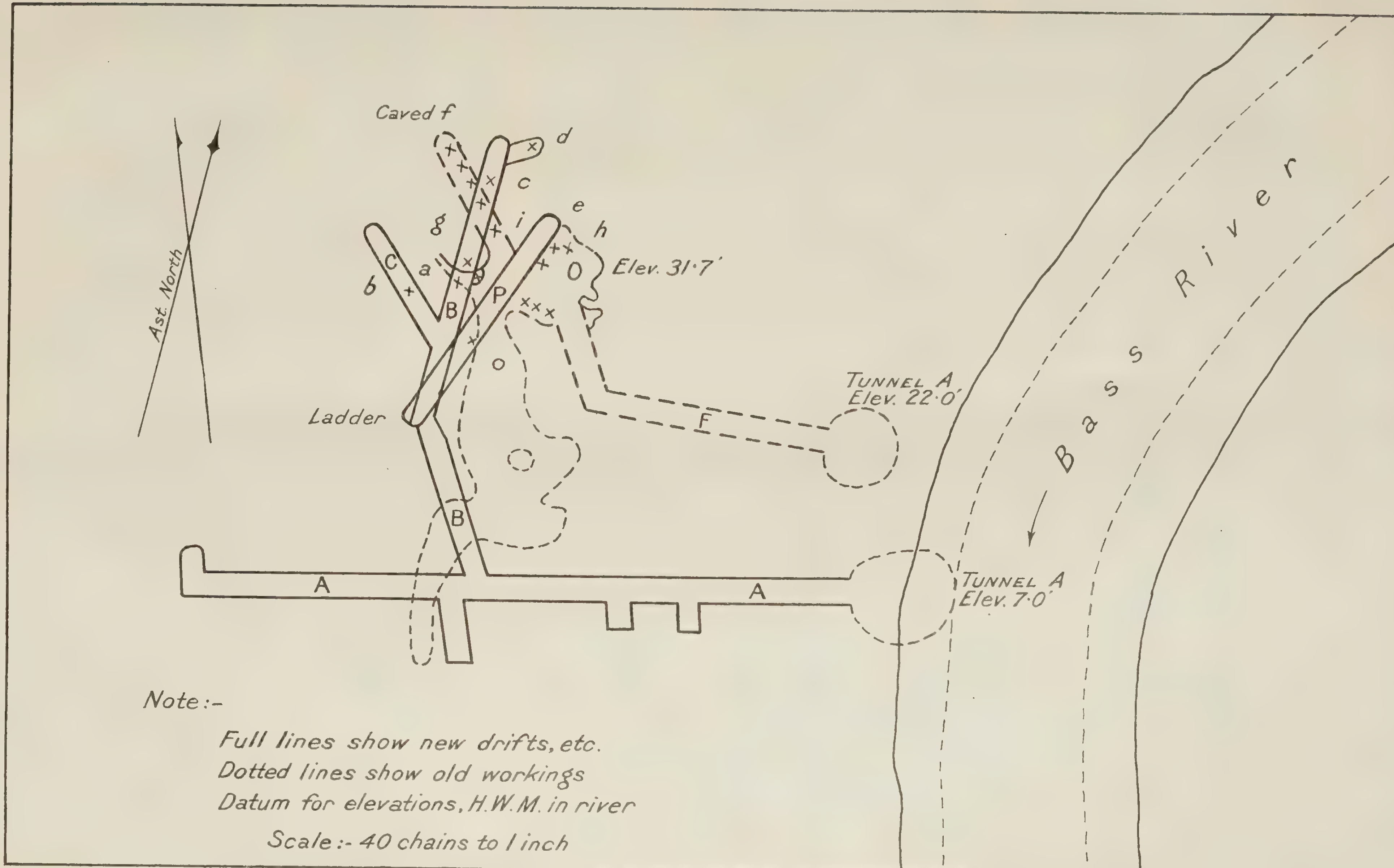


Fig. 3.—Bass River barytes mine, Five Islands, Nova Scotia.

## Hants County

### BROOKFIELD

A deposit of barytes was opened up about the year 1868, six miles east of Brookfield station and one mile west of Bill Putnam brook. The occurrence is often referred to as the Stewiacke barytes deposit.

References to mining operations at this locality are contained in How's "Mineralogy of Nova Scotia," and the data given are abstracted in later reports of the Geological Survey.[1]

According to the above-mentioned reports, the barytes occurred in three veins, averaging not more than 18 inches wide. The ore is said to have been free of sulphides, but to have contained a little graphite. In general, the colour was good.

A production of 1,200 tons of barytes is reported from this property between 1860–70. Mining has been undertaken intermittently since that time, the last operations being conducted in 1899, by Messrs. Henderson & Potts, of Halifax; only a small tonnage was produced.

According to Fletcher's map[2], the deposit lies at or near the contact of Devonian and Carboniferous limestone. How states that the veins traverse irregularly a grey, somewhat argillaceous, limestone.

Barytes also occurs, mixed with limonite, near the iron mine at Upper Brookfield.

### Other Localities in Nova Scotia

References to the occurrence of barytes in various other parts of Nova Scotia are to be found in the older reports of the Geological Survey, more particularly in the Reports of Progress for the years 1879–80, Part F, and 1882–84, Part H; also in Jackson and Alger's "Geology of Nova Scotia," 1832; J. W. Dawson's "Acadian Geology," 1855; and How's "Mineralogy of Nova Scotia," 1869.

Among the localities mentioned are: Bridgeville and Hodson, in Pictou county; near Port Hood, Brook Village, Judique, and Finlay Point, all in Inverness county, Cape Breton; near Loch Lomond, L'Archevêque and McMillan Point, in Richmond county; on the south branch of Black brook, near Springhill, Atkinson Siding, and near Greenville, in Cumberland county; Great Village, Londonderry iron mines and Onslow, in Colchester county; near Arisaig, Antigonish county; Walton and Pembroke, in Hants county. Of the above-mentioned occurrences, only that at Hodson, five miles from River John, in Pictou county, appears to possess any possible economic importance. There, the barytes is stated[3] to occur in small veins and lenses, in sandstones of the Upper Carboniferous series. A small production (500 tons) was reported between 1870–80. No further mining has taken place. At the majority of the above-noted localities, the barytes occurs in Carboniferous rocks, and is found filling drusy cavities in iron ore, limestone, or sandstone; veins of workable size are rare.

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[1] Geol. Surv. Can., Ann. Rep.,Vol. V, Part II, 1890–91, p. 192P; Mineral Resources Bulletin, No. 953, 1907, p. 16.
[2] Geol. Surv. Can., Truro Map Sheet, No. 57, 1902.
[3] H. S. Poole, loc. cit., p. 14.

## NEW BRUNSWICK

Barytes occurs[1] in veins traversing Pre-Cambrian limestones, on Frye island, and near North Head, Grand Manan island, both in Charlotte county.

At Gouldville, near Memramcook, Westmorland county, barytes occurs in red sandstones and shales of the Lower Carboniferous series. Bailey[2] states that several pits were opened on this deposit many years ago, and that a small tonnage was shipped. The ore, however, proved to be of low grade. Small amounts of galena occur, associated with the barytes.

## ONTARIO

### Northern Ontario

The occurrence of barytes deposits in northern Ontario has been known only since 1910; the first occurrence to which attention was drawn being that in Langmuir township, Porcupine mining division. Later, the deposits in the Elk Lake-Matachewan district attracted attention, and the Tionaga occurrence in Penhorwood township, west of Sudbury, was discovered in 1917.

None of these deposits have, as yet, attained the status of producers, but that in Langmuir township has had a considerable amount of development work done upon it, and a mill has been erected on the property. This property, though 35 miles from rail, has the advantage of being able to ship this entire distance by water, and thus is more favourably situated as regards transportation than any of the others in the same region. Until better transportation facilities exist to the Elk Lake-Matachewan deposits, it is out of the question to make any attempt at development. The Tionaga deposit appears to contain a considerable tonnage of good barytes; and being situated close to the railroad, should prove capable of profitable development.

## Sudbury District

### SUDBURY MINING DIVISION

#### Township of Penhorwood

*Cryderman or Ravena property.*—This property lies $2\frac{1}{2}$ miles west of Tionaga station, on the main line of the Canadian National railway, one hundred and thirty-five miles west of Sudbury. (See Fig. 6). It comprises two claims, each 1,320 feet square, recorded at Sudbury as S4419 and S4421, and is controlled by C. H. Hitchcock and associates, of Sudbury, Ont.

Discovery of barytes at this point was made about 1917, but no active mining operations have as yet been undertaken. The owners have, however, done a considerable amount of surface stripping and trenching; and during 1920, six diamond drill holes, totalling 1,012 feet, were put down. Stripping operations have proven an ore-body with a length of 540 feet, and consisting of several more or less parallel barytes veins, separated by either granite, altered greenstone, or massive white quartz.

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[1] Geol. Surv. Can., Ann. Rep., Vol. X, 1897, Part M, p. 125.
[2] Ibid.

The accompanying plan, Fig. 4, shows the course of the barytes veins, as indicated by stripping and drilling. The percentages of barium sulphate given on the plan are for channel samples taken across the veins at the points indicated, the figures being furnished by the owners. The writer's examination showed, however, that the leads, as indicated, are not to be taken as carrying uniformly clean barytes; the veins, especially in their widest portions, are inclined to finger out into a number of barytes stringers, separated by either granite or white quartz. In mining these zones, therefore, a considerable amount of cobbing would have to be done, in order to secure clean barytes. The maximum width of the ore-body proper (including the mixed zones) is about 16 feet, at the most northerly outcrop. (Plate V). Drilling has proved ore to a depth of 150 feet, and the owners report a proven tonnage of 50,000 tons.

The barytes has been deposited at or near the contact of granite pegmatite with greenstone (hornblende schist). The contact seems to be in the nature of a minor shatter zone upon which considerable quantities of white quartz have formed; through this quartz-pegmatite run the barytes leads, and it seems probable that the deposition of the latter mineral has followed lines of secondary fracturing, caused by a later intrusion of diabase. While diabase was not observed in proximity to the deposit, a dike of this rock is reported as exposed a short distance to the south, and it is also shown in the drill cores. The generally heavy overburden prevents close study of the rock relationships at this locality. According to T. L. Tanton,[1] the region consists mainly of a schist series, made up of altered volcanic rocks—andesite, rhyolite, porphyry, and tuffs—intruded by batholithic granite, syenite, and gneiss. All these rocks are of Pre-Cambrian age, and form part of the great basement complex.

The barytes is of excellent quality, being of a good white colour, and practically free from deleterious accessory minerals, such as sulphides, fluorite, etc. Purple fluorite is conspicuous in the granite adjacent to the veins, and quartz stringers traversing the granite frequently carry this mineral; it was not observed, however, to occur in the barytes leads. The bulk of the ore is very fine-grained, closely resembling massive gypsum in appearance. Interspersed, tabular crystals of colourless barytes occur throughout this ground mass, and, locally, such crystals may predominate.

A bulk sample of forty pounds, said to consist of material taken from the several exposures on the property, was analysed in the laboratory of the Mines Branch, and proved to contain:—

| | |
|---|---|
| Barium sulphate | 97·5 |
| Silica | 2·3 |
| Lime | Trace |

The average of the six samples taken at the points indicated on the plan (Fig. 4), shows 95·5 per cent barium sulphate.

A representative sample of the barytes from this deposit, ground to pass 200 mesh, unbleached, and tested for colour against a standard sample of prime white, paint barytes, showed clear white, and is equal if not superior to the standard.

The deposit, which strikes north, and has a vertical dip, is exposed on a low ridge or knoll surrounded by swampy ground; and any further extensions of the vein, either to the north or south, are buried beneath a

[1] Map No. 1697, Geol. Surv. Can., 1916.

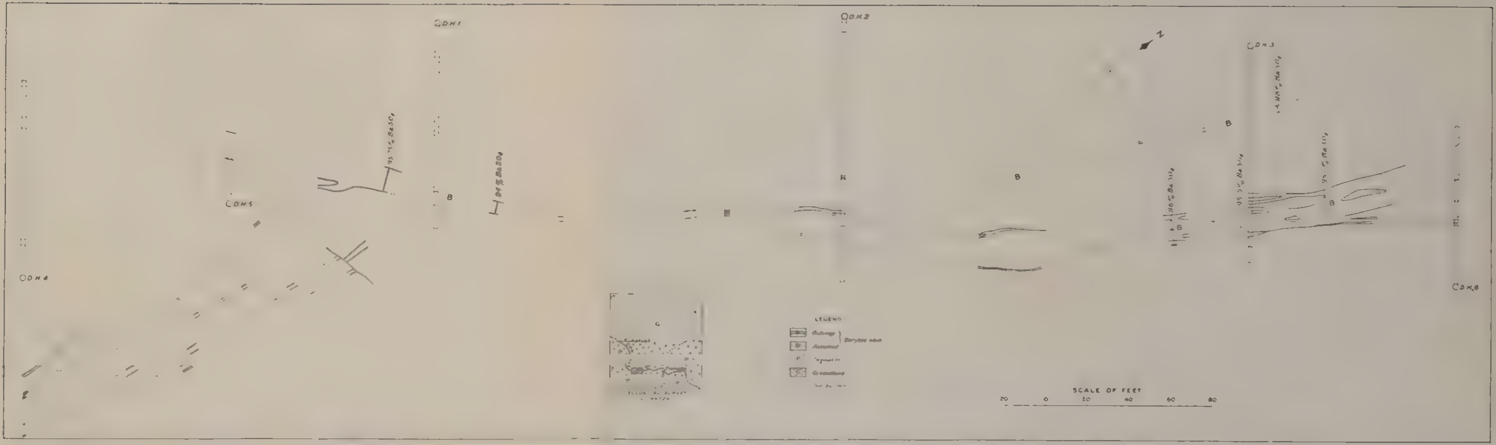



Fig. 4 – Plan of [illegible] deposit near [illegible], Sudbury district, Ontario, showing location of diamond drill holes. [illegible] H. Hitchcock.

32158—To face page 36

heavy swamp overburden. The vein follows approximately the crest of the knoll, parallel to its longer axis, the highest outcrop being forty feet above the surrounding swamp.

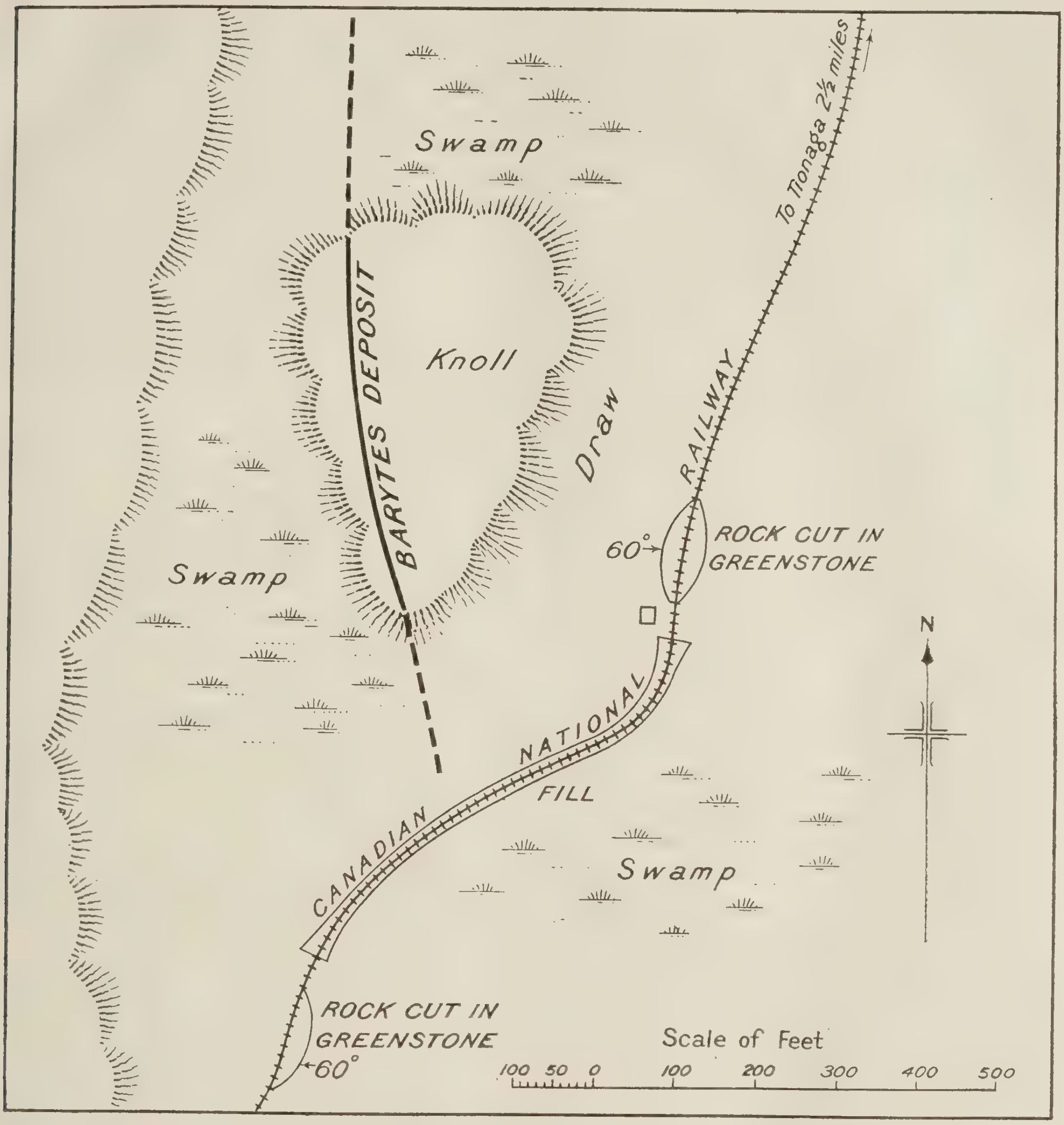



Fig. 5.—Sketch plan of Cryderman barytes deposit, near Tionaga, township of Penhorwood, Sudbury district, Ont.

The deposit lies within five hundred feet of the railway, but considerably below the level of the track, and the nature of the terrain will necessitate the laying of a spur of about half a mile, if ore is to be dumped directly into railway cars.

When visited (September 1920) there were no improvements, such as buildings, equipment, or roads, on the property.

Approximate freight rates (September 1920) for the crude ore to eastern points are, per ton:—

| | |
|---|---|
| Sudbury | \$1.50 |
| Toronto | 4.05 |
| Niagara Falls | 4.88 |
| Ottawa | 4.38 |
| Montreal | 6.00 |

## Timiskaming District

### GOWGANDA MINING DIVISION

#### Township of Cairo

*Biederman claim.*—This deposit is situated in the north part of Cairo township, on the west shore of Browning lake. (See Fig. 6). It is reached by water route from Elk Lake (as described under the Ontario Barium Company's property in Yarrow township) as far as Fox rapids, from which point a good bush road extends to within a mile of the claim. The distance from rail at Elk Lake is about 27 miles.

Bush fires have destroyed the timber in the vicinity of the deposit, which lies on a ridge of syenite, rising about 75 feet above the lake. This ridge strikes north, following the west side of the lake and falls fairly steeply to the water. There is very little overburden around the barytes deposit, and only a light growth of poplar brush. The slope of the ridge toward the lake is littered with loose rock, and no attempt has been made to strip the barytes lead in this direction.

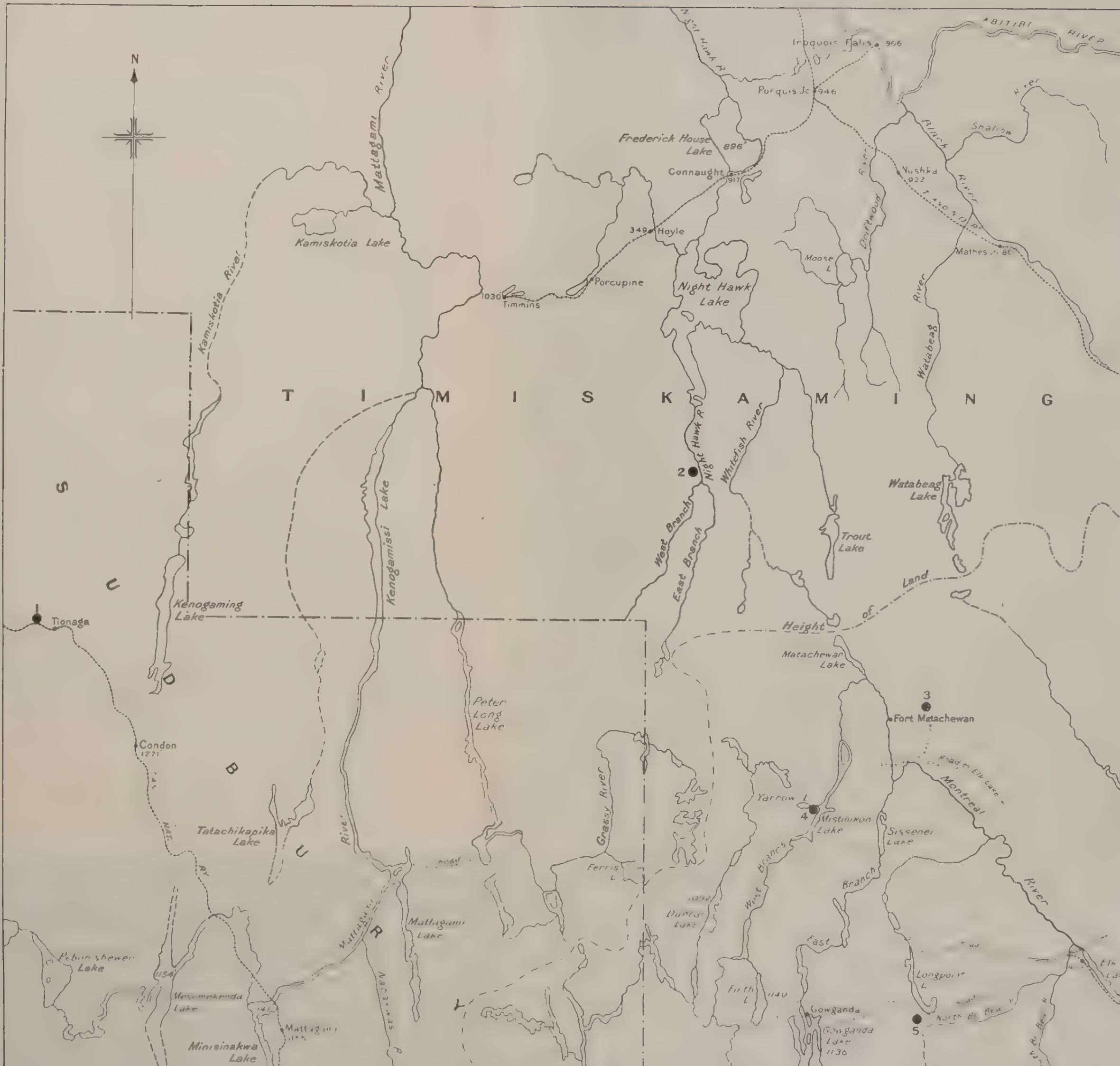
The claim on which the barytes occurs is patented, and is numbered 16042. The owner is Mrs. L. Biederman, of Sesekinika, Ont.

The barytes occurs on a well-defined vein, striking N. 65° W., and at right angles to the course of the ridge. The sinking of a pit 6 × 6 feet, and 15 feet deep, on the shoulder of the ridge, and the removal of the comparatively thin covering of soil along the vein, constitute the whole of the development work undertaken. The vein is practically vertical, with a very slight dip to the north. Where opened up in the pit, the vein has a width between walls of 16 feet, but the vein matter contains horses and fragments of country rock, which would render cobbing of much of the ore necessary. The vein exhibits its maximum width at this point, and narrows to 9 feet of clean barytes at 40 feet west of the pit. It has been stripped for a total distance of 85 feet; beyond this point the rocks are hidden beneath a light dirt covering. At 100 feet from the shoulder of the ridge and 25 feet to the north of the main lead, a small barytes stringer, 2 feet wide, outcrops for a distance of 20 feet. No other veins were observed.

The barytes of this deposit is neither so clean nor of such good colour as that of the deposits in Yarrow and Lawson townships. Much of the surface ore has a pinkish or brownish tinge; small amounts of sulphides—galena, zinc blende, and chalcopyrite—and also of purple fluorite, occur along the contacts, but were not noticed in any quantity in the vein proper. The principal impurity in the ore is silica, which appears to be present as an accessory constituent throughout much of the vein. In addition, a siliceous zone, as much as 30 inches wide at one point, appears to persist along the hanging (north) contact; this zone consists of a fine-grained, barytes-quartz matrix, carrying stringers and interspersed crystals of coarser, spathic barytes. Such a zone is absent on the foot-wall. Both coarsely spathic and fine-grained barytes occur in the body of the vein.

The deposit is enclosed in a reddish-brown, aplitic, hornblende syenite, which covers an area of about 30 square miles in Cairo and Alma townships. The age of this syenite is given by H. G. Cooke as Pre-Huronian and Post-Keewatin.[1] No other intrusive types were observed in the immediate vicinity of the deposit, but a large dike of diabase, with a direction north and south, or normal to the barytes vein, occurs a few hundred yards to the south.

[1] Geol. Surv. Can., Memoir No. 115, 1919, p. 31.




Barytes properties
1. Cryderman or Ravena
2. Premier Langmuir
3. Biederman
4. Ontario Barium Company
5. Eby or Scott

Fig 6—Sketch map showing barytes deposits in Sudbury and Timiskaming districts, Ontario. Scale: 8 miles to 1 inch.

32158—To face page 38

An analysis, made in the Mines Branch laboratory, of a representative sample taken across the entire width of the vein, and including the siliceous zone referred to above, yielded:—

| | |
|---|---|
| Barium sulphate | 74·85 |
| Silica | 16·80 |
| Calcium carbonate | 2·93 |

A sample[1], taken across 8 feet of vein, gave 90·50 barium sulphate.

A representative sample of the barytes from this deposit, ground to pass 200 mesh, unbleached, and tested for colour against a standard sample of prime white, paint barytes, exhibited a distinct light grey cast.

References,—

Ont. Bur. Min. 27th Ann. Rep. 1918, Part I, p. 237[1] (with maps): 29th Ann. Rep., 1920, Part III, p. 64.

Geol. Sur. Can., Memoir No. 115, 1919, p. 41 (with Map No. 1793.)

**Township of Lawson**

*Eby or Scott claim.*—Situated about fifteen miles west of Elk Lake, the present terminus of the Elk Lake branch of the Timiskaming and Northern Ontario railway. (See Fig. 6). The property lies one mile south of the Elk Lake-Gowganda wagon road, but is not connected with the latter by either road or trail. There are no heavy grades between the deposit and the road, and a fairly direct mine road could be built. Ore would have to be hauled by team or truck sixteen miles to Elk Lake.

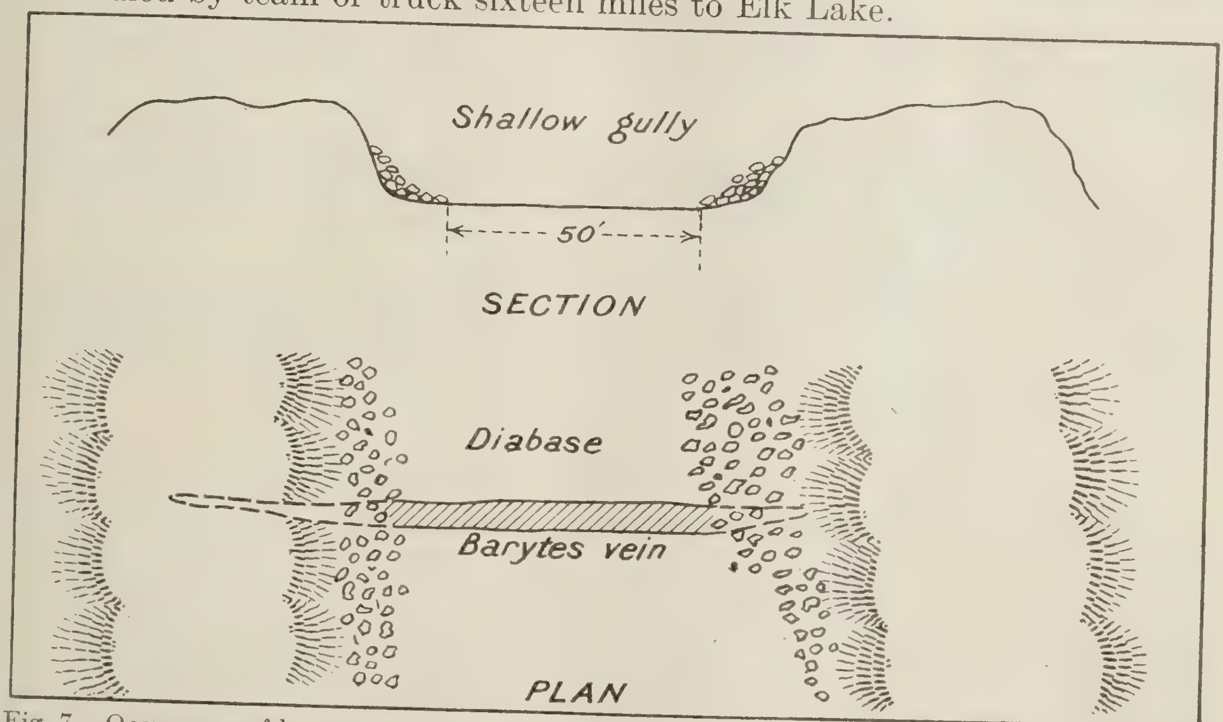



Fig. 7.—Occurrence of barytes on Eby or Scott claim, township of Lawson, Timiskaming district, Ontario.

The claim comprises thirty-six acres, and is numbered MR 3308/ D.G. 23, Gowganda mining division. The present lessee is H. Douglas Eby, Front street, Toronto. Hardly any work has been done on the property; a few shallow shots were put in on the vein some years ago, but no attempt has been made to trace the lead beyond its visible outcrop.

The deposit consists of a single vein of massive barytes, ten feet wide at its widest point, but averaging eight feet. The exposed length is fifty feet, the vein crossing a small depression between two parallel ridges,

seventy-five feet apart. The strike of the lead is east, and the dip approximately vertical. The vein appears to be cut off to the west by the cross ridge, and pinches to a small stringer in the face of the east ridge. (See Fig. 7).

The enclosing rock is Nipissing diabase, and the deposit is, presumably, of similar age to the silver veins of the region.

The barytes is of very good quality, and is practically free from objectionable impurities in the shape of sulphides, fluorite, etc. The ore consists of a close aggregate of large, platy crystals, ranging from white to colourless; the latter often exhibiting a high degree of iridescence. Some stained material was noticed, but much even of the surface ore is only slightly off-colour. The barytes of this deposit, in common with that from other northern Ontario localities, differs radically from the finer-grained, pink or cream coloured, opaque, barytes of the southern part of the province.

A grab sample of surface ore, taken from a number of points on the outcrop, and analysed in the laboratory of the Mines Branch, yielded:—

| | |
|---|---|
| Barium sulphate | 98·03 |
| Strontium sulphate | ·70 |
| Calcium sulphate | 1·20 |
| | 99·93 |

A smaller sample, submitted to the Titanium Pigment Company, of Niagara Falls, and analysed by them, gave 99·26 per cent of barium sulphate.

A representative sample of the barytes from this deposit, ground to pass 200 mesh, unbleached, and tested for colour against a standard sample of prime white, paint barytes, showed clear white, and was equal if not superior to the standard.

While the quantity of ore available cannot be estimated as large, the material ranks as a very superior grade of barytes. Development of the property, however, can hardly be undertaken without improved transportation facilities.

### Township of Yarrow

*Ontario Barium Company's Property.*—Situated about 3 miles south of the north boundary of Yarrow township, on the west side of Mistinikon (Kenisheong) lake, which forms part of the west branch of the Montreal river. The locality can best be approached by water route, either by way of Long Point lake, 13 miles west of Elk Lake on the Gowganda road, or up the main Montreal river, from Elk Lake. (See Fig. 6.) The latter route, covering a total distance of about 35 miles, is the more convenient, since a motor boat service is maintained in the open season from Elk Lake to Indian chutes, a distance of 12 miles, and from above Indian chutes to the foot of Long rapids, another 5 miles. From the head of Long rapids, transportation is by canoe to the confluence of Davidson creek, 8 miles farther, whence a portage of 3 miles leads to the west branch. A wagon road has been projected from Elk Lake to Davidson creek (Moyneur's or Otisse landing), a distance of about 30 miles. This road, connecting with a winter road of 7 miles to the deposit would afford the only route by which ore could be shipped out to rail.

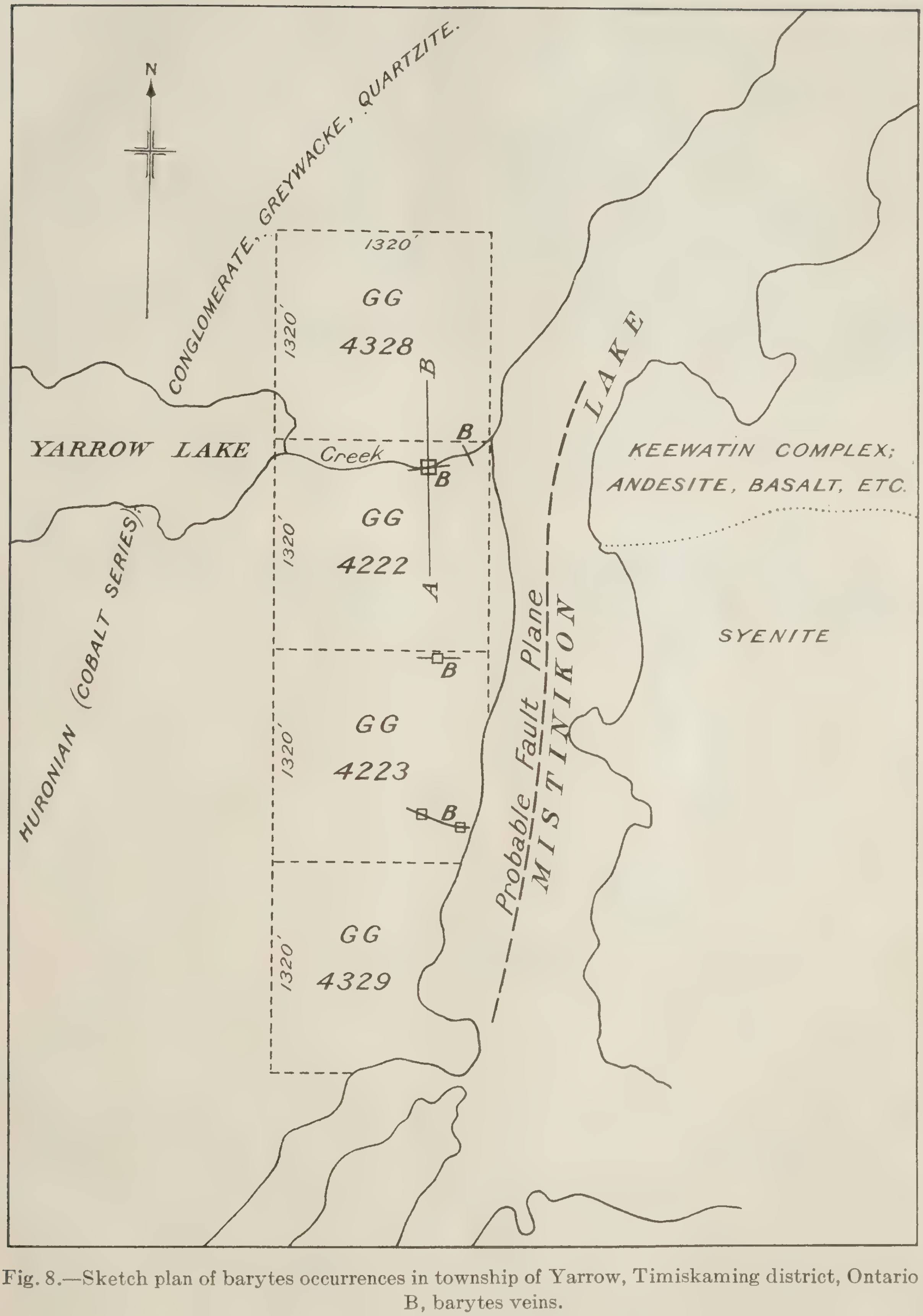



Fig. 8.—Sketch plan of barytes occurrences in township of Yarrow, Timiskaming district, Ontario B, barytes veins.

The property comprises four claims, Nos. GG4222, 4223, 4328, and 4329, each of forty acres. The claims are unpatented, but have been surveyed for patenting during the past year (1920). Only Nos. 4222 and 4223 are known to carry barytes. The property is controlled by the Ontario Barium Company, 707 Royal Bank building, Toronto. No attempt to mine ore for shipment has ever been made, but a considerable amount of stripping and trenching has been carried out, resulting in the proving up of two promising barytes leads. The leads run approximately at right angles to the shore of the lake, the outcrops being situated within a few yards of the water. The accompanying plans, Figs. 8, 9, and 10, show the location of the claims and character of the deposits.

The country in which the deposit lies is very rough, and heavily timbered. While not attaining any important altitude, the hills and ridges are yet high enough to confine transportation routes to the existing portages.

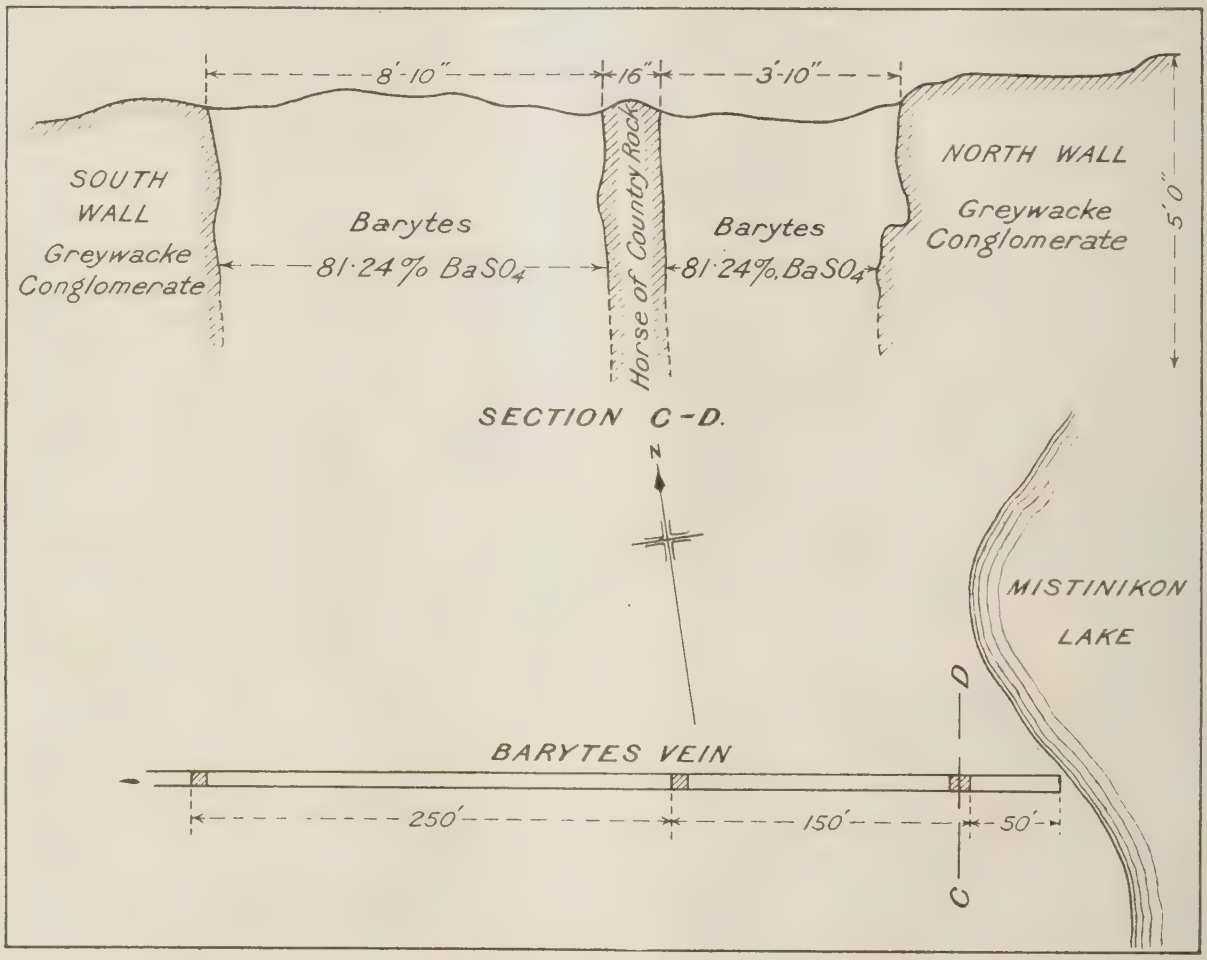



Fig. 9.—Occurrence of barytes on claim 4223, township of Yarrow, Timiskaming district, Ontario.

The larger of the two barytes veins occurs on claim No. GG4223. (See Fig. 9). Its outcrop is at the edge of the lake, the width being 5 feet between walls. Fifty feet to the west, a few surface shots have opened a shallow pit, which discloses a vein width of 14 feet; several relatively narrow strips or "horses" of country rock are enclosed in the vein matter at this point. The vein strikes N. 73° W., and dips steeply to the north. Proceeding westward from this first pit, the ground commences to rise somewhat steeply, and the rocks are concealed beneath a considerable thickness of drift. At a point 450 feet west of the lake shore, trenching has uncovered

the vein beneath 8 feet of drift, and a pit 8 feet square and 8 feet deep has been sunk, the vein showing 11 feet of solid barytes. The above represents all the development work done upon this lead, and shows the existence of an ore-body at least 450 feet long, with an average width of probably not less than 5 to 6 feet. The well-defined vein walls, and the general character of the vein at the most westerly exposure, suggest that the lead may extend considerably farther in this direction.

The barytes of this lead varies somewhat in character. In general, it is coarsely spathic, often yielding cleavage pieces several inches across; locally, however, the grain becomes finer, and in some cases is hardly distinguishable, the ore being dense and compact, with a few interspersed large crystals. Little in the nature of accessory mineral impurities can be seen at any of the exposures, the chief being specularite and chalcopyrite, in minute quantities. The presence of thin films of specularite between cleavage plates of barytes is probably the cause of the purplish tint possessed by much of the ore, especially that at the walls. Most of the barytes possesses a greyish tint, relatively little of the material being clear white. This shade is inherent, however, and is not due to discoloration by staining; even the darkest grey ore appears to yield a good white product on grinding.

The vein is enclosed in a somewhat ferruginous greywacke-conglomerate[1] of Pre-Cambrian age, and belonging to the Cobalt series. This rock varies in colour from green to brownish-red, and carries large included boulders of red granite. No igneous rocks were observed in the immediate vicinity of the deposit; but an area of syenite occurs a few hundred yards to the east, on the other side of the lake.

The following analyses are of material taken from this vein:—

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Barium sulphate | 98·67 | 98·25 | 94·00 | 99·80 | 96·08 | 81·24 |
| Strontium sulphate | ·70 | ...... | ...... | ...... | ...... | ...... |
| Calcium sulphate | ·30 | ...... | ...... | ...... | ...... | ...... |

1. Selected sample: analysed in Mines Branch laboratory.
2. " : analysed by Provincial Assay Office, Toronto.
3. " : analysed by Ontario Bureau of Mines.
4. " : analysed by Grasselli Chemical Company, Cleveland.
5. " : analysed by Titanium Pigment Company, Niagara Falls.
6. Channel sample: analysed by Toronto Testing Laboratory, Ltd.

A second barytes vein, approximately parallel to the foregoing, occurs on claim No. 4222, several hundred feet to the north. This vein outcrops in the bed of a small creek, flowing through a shallow gully; no development has taken place on this lead, beyond the shooting out of a few tons of surface ore, but the vein is reported to have been picked up 700 feet farther to the west, and to show 7½ feet of solid barytes. The heavy overburden at this point renders stripping operations difficult. The vein has a width between walls of 20 feet, but is divided down the middle by a band of included country rock 6 feet wide, which divided it into two portions, respectively 7½ feet and 6½ feet thick (Fig. 10). The vein is exposed for a distance of about 20 feet in the creek bottom. The general character and mode of occurrence of the barytes here are essentially the same as on

[1] See A. G. Burrows, Vol. 27, Part I, Ont. Bur. Min., 1918, with accompanying Map No. 27A.

the vein described above. A channel sample across the 6½ feet of ore, lying against the south wall of the vein, gave 77 per cent of barium sulphate. (Analysis by Toronto Testing Laboratory, Ltd.)

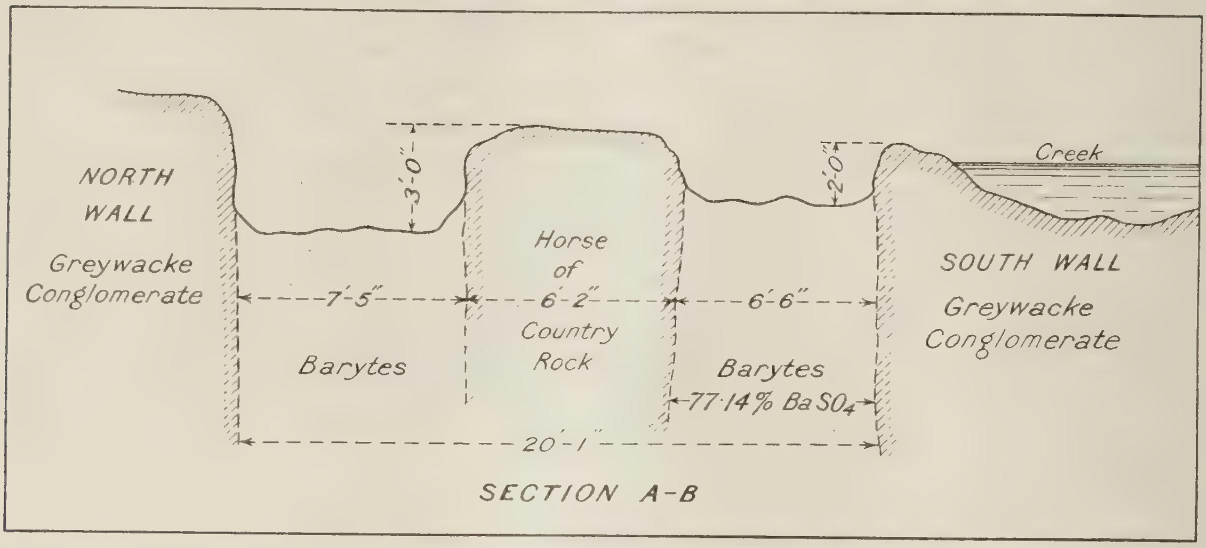



Fig. 10.—Section through barytes vein on claim 4222, township of Yarrow, Timiskaming district, Ontario.

A third barytes vein, having a strike of N. 40° W., is partly exposed in the south bank of the same creek, nearer the lake; ore is reported to be exposed at this point for a width of 4 feet. In addition, stripping operations about midway between the two main leads have disclosed several feet of ore on what is, apparently, a fourth vein.

The development work already carried out shows the existence on this property of a large tonnage of excellent barytes. The character of the exposed veins warrants the assumption that further stripping will show them to persist considerably beyond the present determined points.

A representative sample of the barytes from this property, ground to pass 200 mesh, unbleached, and tested for colour against a standard sample of prime white, paint barytes, proved a decided shade whiter than the standard. Despite the brownish cast of the crude ore, this barytes yielded the whitest ground product of all the samples examined.

References:—

Ont. Bur. Min., 27th Ann. Rep., 1918, Part I, p. 238 (with map); 29th Ann. Rep., 1920, Part III, p. 64. Geol. Surv. Can., Memoir No. 115, 1919, p. 41 (with map No. 1793).

## PORCUPINE MINING DIVISION

### Township of Langmuir

*Premier Langmuir Mine.*—Situated on the east branch of Night Hawk river, 35 miles due south of Connaught station, on the Porquis Junction-Timmins branch of the Timiskaming and Northern Ontario railway. (See Fig. 6.) The property is reached in the open season by water from Connaught, up the river joining Night Hawk and Frederick House lakes, to the head of the former lake, and thence up the Night Hawk river. The water of Night Hawk lake was lowered materially in 1909, by the cutting away of retaining clay at High Falls, on the Frederick House river. The construction of a dam higher up the river, at Connaught, helped to retain the water in the lake, but navigation during the latter part of the

season is difficult for any but the lightest draughts, on account of the numerous shoals. The owners of the property report, however, that several shipments of barytes have been successfully carried by 40-ton scow from the mine to Connaught.

The mine workings and mill are located on the west bank of the river, about 700 yards from the wharf, and connected with the latter by a tramway. Barytes can be loaded at the wharf onto scows, which are drawn by motor boat down the winding and narrow Night Hawk river, and across the lake to the railway. The property can also be reached, in winter, by bush road from South Porcupine, 20 miles to the northwest.

Most of the timber around the mine has been burnt, and the rocks and barytes leads are well exposed. The region is one of low relief, and the mine workings are situated at the face and foot of a low, rounded ridge, rising 100 feet above the level river terrace. The deposit is ideally situated for working either by adit or shaft, and both methods have been practised.

The owners and operators of the property are Premier Langmuir Mines, Ltd., 507 Maitland street, London, Ont., who own six claims numbered P 1307 to P 1312, and commenced mining operations in 1915. Intermittent work has been conducted up to the present time, and in 1918 a 30-ton mill was erected and equipped, a small quantity of ore being ground. The mill system installed, however, proved inadequate for the production of ground barytes to meet trade specifications; hence, with the exception of a small trial consignment, no shipments of ground material have been made. The mill has stood idle for the last two years.

The barytes occurs as well-defined veins, of which at least two have been located. These veins are approximately parallel, have a strike varying from N. 30° W. to N. 70° W., and dip vertically. Where the main vein enters the face of the ridge, (see Plate IX), the strike is N. 30° W., but a pronounced swing to the south brings it to N. 70° W. at the most easterly outcrop. This vein is 6 feet between walls at the point of attack, and keeps this width fairly uniformly to the end of the 160-foot adit. The lead can be traced in a southeasterly direction, and with diminishing width, on the surface, for a distance of about 1,000 feet, at which point it approaches the lower front of the ridge, and pinches to a narrow stringer.

The mine workings are chiefly confined to openings on the main vein. They consist of the adit already mentioned, with a length of 160 feet, and a vertical, 130-foot shaft sunk on the lead immediately in front of the adit entrance. At 60 feet, a drift was carried from this shaft for a distance of 80 feet along the lead. At the end of the adit, a small stope has been carried up about 12 feet, the vein there measuring 6 feet between walls.

At a point 175 feet east of the mill, a second parallel and smaller vein is exposed for a distance of 100 feet, following the lower face of the ridge, and may possibly connect with the main vein in depth. The two veins are about 60 feet apart. A shaft 75 feet deep has been sunk at the base of the ridge on this vein, but judging by the ore lying around the opening, the lead does not carry nearly as white barytes as that of the main lead. Sulphides, particularly zinc blende and chalcopyrite, occur in small amount in this ore.

The ridge traversed by the barytes veins is composed of Keewatin greenstone,[1] intruded by small stringers and narrow dikes of what appears to be pyroxene-syenite. The deposition of the barytes has taken place subsequent to the intrusion of this latter rock, since brecciated fragments of both greenstone and syenite, cemented by barytes, are common in the vein. The greenstone is a hard, brittle, and very fine-grained rock, slightly schistose in places, and of a greenish-black colour. Epidote and purple fluorite, the former in small, brilliant crystals and the latter usually as a thin incrustation between barytes and greenstone, are common in the wall-rock bordering the veins, and also in the occasional horses of greenstone encountered in the leads. Sulphides, principally galena, zinc blende, and chalcopyrite, occur in small amount, sometimes as streaks in the vein matter, but more usually associated with the purple fluorite. Native silver is also sometimes met with in the same association.

The principal impurities in the barytes, as evidenced by analysis, are carbonate of lime and silica. The following analyses serve to indicate the composition of the ore:—

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Silica | 0·10 | ...... | 3·95 | 0·50 | 3·08 |
| Calcium carbonate | 3·81 | 21·80 | 9·20 | 3·65 | 8·10 |
| Barium carbonate | ...... | 1·97 | ...... | ...... | 0·62 |
| Calcium sulphate | 3·52 | ...... | ...... | ...... | ...... |
| Strontium sulphate | 3·40 | ...... | ...... | ...... | ...... |
| Barium sulphate | 86·60 | 76·50 | 86·90 | 94·70 | 88·45 |
| Oxides of iron and alumina | ...... | ...... | 0·20 | 0·40 | 0·10 |

1. Sample across the face at end of adit: analysis by E. A. Thompson, Mines Branch.
2. Selected sample: analysis by Titanium Pigment Company, Niagara Falls.
3. Sample of mill product from Company's mill: analysis by R. J. Traill, Mines Branch.
4. Sample of deduster fines from Company's mill: analysis by R. J. Traill, Mines Branch.
5. Average sample of ore from adit: analysis by A. Sadler, Mines Branch.

These analyses indicate that the barytes of this deposit is of relatively low barium content, and without some method of raising its grade, is unlikely to prove suitable for the trades using the best qualities of this mineral. As evident from analysis No. 3, the present mill system effects little, if any, elimination of impurities.

The barytes of the main vein is uniformly of a good colour and is medium- to coarse-grained, dense and compact; there is no approach to platy structure.

A representative sample of the barytes from this deposit, ground to pass 200 mesh, unbleached, and tested for colour against a standard sample of prime white, paint barytes, exhibited a faint blue-grey shade.

### *Mill*

The mill, shown in Plate X, is situated close to the entrance of the adit, and is designed to treat 30 tons of ore per diem (see Fig. 11). The run-of-mine ore, which usually contains a considerable amount of included, brecciated greenstone, is first fed to a jaw crusher, from which it is elevated to a large trommel, composed of four sections, and fitted with progressively coarser-mesh screens. This delivers five sizes—fines, coarse, intermediate, large, and oversize. The oversize passes to a picking belt, where rock is removed, the clean barytes returning to the crusher. The fines

[1] Ont. Bur. Min., Vol. XX, Part II, 1911, p. 9, with accompanying map, and Vol. XXI, Part I, 1912, p. 248.

are sent to the waste dump. The three middle sizes, $\frac{1}{8}$ inch, $\frac{1}{4}$ inch, and $\frac{1}{2}$ inch, pass to separate jigs, which remove the admixed rock. The concentrates from the jigs proceed to a rotary dryer, 5 feet in diameter. This dryer consists of a wooden shell, and heat is supplied by two small, Oxford Gurney stoves, enclosed in a compartment into which the lower end of the

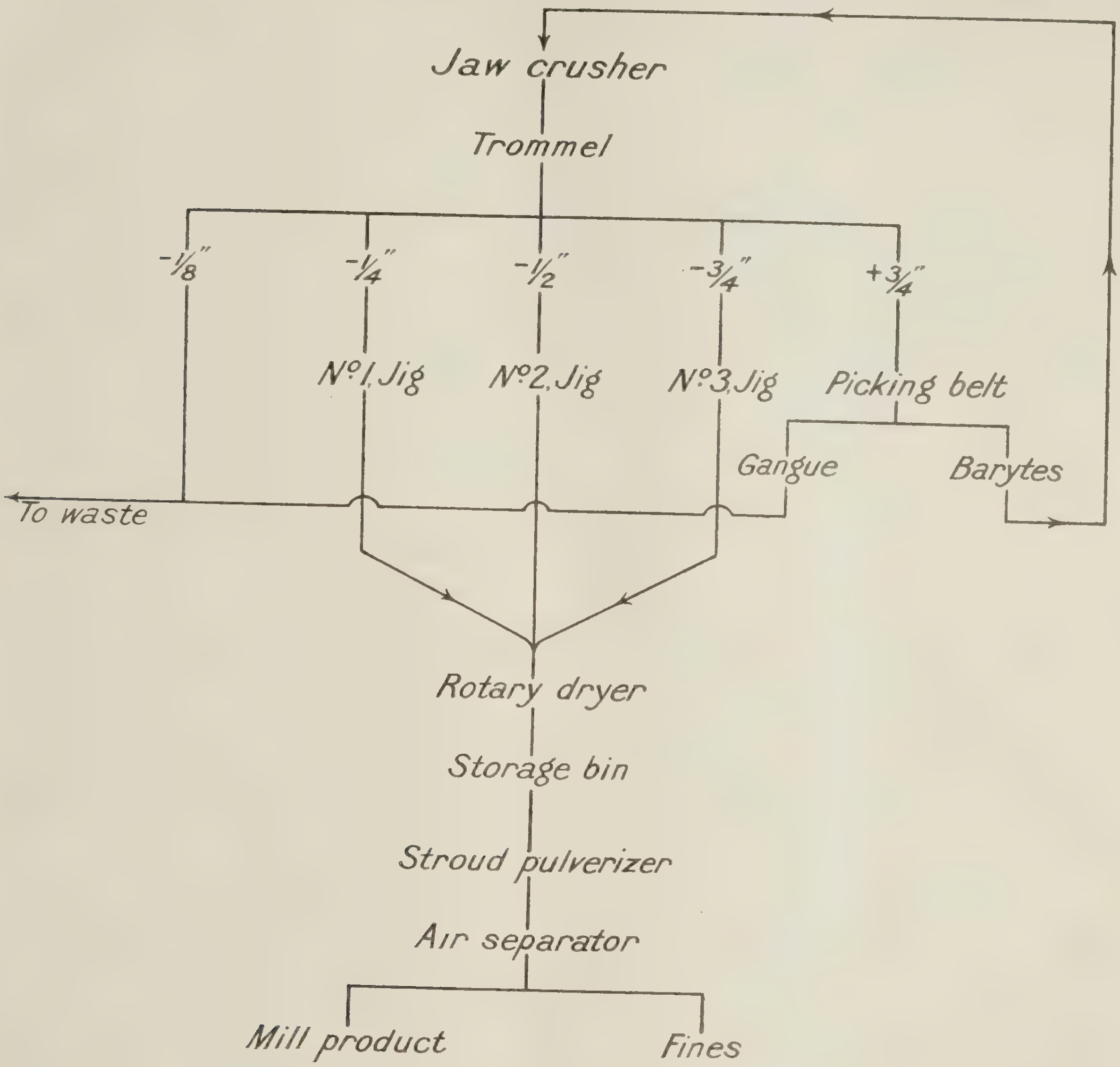



Fig. 11.—Flow sheet at mill of Premier Langmuir Mines, Ltd., Langmuir township, Timiskaming district, Ontario.

dryer projects. The hot air from this compartment is drawn through the dryer shell by a suction fan placed at the upper end of the dryer. The barytes, being all coarser than $\frac{1}{4}$ inch, is said to have all its moisture removed during passage through the dryer. The dried barytes is then elevated to a storage bin, whence it falls to a Stroud Air Separation Pulverizer, (E. H. Stroud and Company, Chicago). This pulverizer works on the swing-hammer principle, and is fitted with a suction air separator and dust collector. Samples of both mill product and dust, analysed in the Mines Branch laboratory, showed that the deduster fines contained 8 per cent more barium sulphate than the mill product, while the latter contained nearly three times as much calcite and eight times as much silica. As already noted, the mill product differs but little in composition from the

crude ore. A screen test of the two materials showed that of the deduster fines, 98 per cent passed 200 mesh, and of the mill product, 88 per cent.

The mill is also equipped with two sets of horizontal buhr stones, but their use was discontinued in favour of the Stroud pulverizer.

Power for the mill and mine hoist is furnished by one 150-H.P. Goldie McCulloch engine; while a small auxiliary engine drives a dynamo furnishing current for lighting and pumping water from the river to the mill.

This deposit is capable of yielding a large tonnage of barytes, and constitutes one of the most important known Canadian barytes occurrences.

## Southeastern Ontario

Scattered deposits of barytes occur in that part of southeastern Ontario bounded by Renfrew and Hastings counties, on the west, and Carleton and Leeds counties, on the east. The deposits are all of vein type, and are found both in the Pre-Cambrian, crystalline rocks (usually Grenville limestone, but sometimes, also, gneiss) and in the Palæozoic sediments overlying these rocks. There seems no reason to doubt, taking the general similarity of the deposits and the ore they carry into account, that most of the barytes occurrences in this region are of relatively similar age, and were formed subsequent to the laying down of the greater part of the Ordovician rocks; deposition of the barytes taking place on fissures and fracture planes, formed during a period of pronounced faulting, and extending down through the bedded sediments into the basal, crystalline rocks. Those veins at present found traversing the Pre-Cambrian limestones and gneisses, doubtless originally extended upward through considerable thicknesses of Palæozoic sediments, since removed by denudation. Whether the source of the barytes is to be sought in the overlying Palæozoic rocks, from which it has been deposited by a process of leaching, or whether it is to be ascribed to ascending solutions from the crystalline series, is uncertain. The fact that fluorite is often a conspicuous, accessory constituent of the barytes veins, tends to indicate an origin due, at least in part, to hydro-thermal agency.

In this connexion, it is interesting to note that considerable barytes often occurs in the fluorite veins of the Madoc district, Hastings county, which district lies slightly west of the area here under consideration. In these veins, several generations of barytes often occur; massive barytes frequently lining the walls of the leads, with fluorite composing the central portions. In drusy veins, an incrustation of "crested" barytes often occurs upon the fluorite crystals. At certain of the mines, barytes occurs in sufficient amount to be sorted out as a by-product. Celestite replaces barytes, either wholly or in part, at a few of the mines.

M. Wilson, in a recently issued report[1] on the Madoc fluorite deposits, sees a close similarity between these deposits and the barytes veins of the district here described, and suggests that both probably have a similar origin. The following possible modes of origin for the Madoc fluorite veins are discussed in the report mentioned:—

1. Leaching of the vein material from adjacent sedimentary rocks through the agency of meteoric waters.
2. Leaching of the vein material from adjacent sedimentary rocks by ascending heated waters.
3. Interaction of descending solutions carrying lime, derived from adjacent sedimentary rocks, with ascending magmatic waters carrying fluorine, etc.
4. Deposition from heated, magmatic waters carrying all the vein material in solution.

[1] Geol. Surv. Can., Summary Report, Part D, 1920, pp. 49-53.

Wilson presents the evidence for and against each of the above possible modes of origin, but abstains from a definite conclusion regarding the genesis of the deposits.

Few of the barytes veins in southeastern Ontario attain economic dimensions. Those found enclosed in gneiss are in every case merely narrow stringers. Certain of those found traversing Pre-Cambrian, crystalline limestone have been worked in a small way; but this class, also, does not exhibit important economic possibilities. The same applies to the veins found in the Palæozoic limestones. While these last deposits, in some cases, possess greater width than those of the two former types, they often contain a great deal of brecciated country rock, the barytes occurring as a cementing medium for the rock fragments. In some cases, the rock matter in deposits of this type preponderates over the barytes.

The ore from most of these deposits contains a certain amount of strontium, as much as 6 per cent of strontium sulphate being found in one sample. Several deposits of celestite (strontium sulphate) occur in the same region, and under the same general conditions as those noted above.

The above remarks are applicable, also, to the barytes deposits in Pontiac, Hull, and Labelle counties, in the province of Quebec, where similar geologic conditions obtain.

## Carleton County

### Township of Fitzroy

*Concession II, lot 4.*—This deposit is situated 6 miles, by road, south of Kinburn station, on the Ottawa-Parry Sound line of the Grand Trunk railway. The owner of the property is John Currie, Kinburn, Ont.

A few shallow prospect pits have exposed a body of barytes on this lot, but the work done is not sufficient to disclose the true character or extent of the deposit. The largest pit shows a body of brecciated, Ordovician limestone, cemented by barytes. A quantity of soft, banded, tuff-like material is present, and proved on analysis to be a mixture of barytes and carbonate of lime in the proportion of 82 to 15 per cent.

The barytes is soft, massive, and of a greyish-white shade. Some of it possesses a brownish cast, as if coloured by hydrocarbon. Fragments of brown limestone are scattered throughout the ore-body, and form perhaps about half its mass. It would be quite impracticable to clean the material of this brecciated zone by cobbing. None of the surface ore is white enough to yield a No. 1 grade of barytes. The cover of Palæozoic rocks at this point is, however, relatively thin, and it is possible that a better grade of ore would be encountered as soon as the breccia zone in the sedimentary series was passed, and the vein entered the underlying, Pre-Cambrian rocks.

The vein trends east, and outcrops are stated to occur for a considerable distance; none of them, however, have been worked.

The following analyses of material from this deposit were made in the Mines Branch laboratory:—

| | 1 | 2 |
|---|---|---|
| Barium sulphate | 92·50 | 82·39 |
| Strontium sulphate | 1·00 | ...... |
| Calcium carbonate | 5·00 | 15·53 |

1. Mixed barytes and limestone breccia.
2. Calcite-barytes tuff.

A representative sample of No. 1, ground to pass 200 mesh, unbleached, and tested for colour against a standard sample of prime white, paint barytes, possessed a drab grey (putty) colour, while No. 2 showed a light cream tint.

## Frontenac County

### Township of Kingston

*Concession IV, lots 16 and 17.*—Situated near Counter's Corners, on the main road, about six miles northwest of Kingston, and one mile from the track of the Kingston and Pembroke branch of the Canadian Pacific railway.

The deposit of barytes exposed on the above lots can be traced[1], by means of scattered outcrops, as far as Varty lake, a distance of 14 miles. Mining has been conducted only at this point, and, to a more limited extent, on the adjacent lots (concession V, lots 15 and 16) to the northwest. About 100 tons of ore is reported to have been taken from the openings on these lots over twenty years ago. The barytes was ground in a local flour mill, and utilized in paint manufacture. The present owner is J. Woodruffe, Cataraqui, Ont.

The barytes occurs as a well-defined, vertical vein in horizontally-bedded Black River (Ordovician) limestone. The vein strikes northwest, and has a maximum width of 3 feet at the northwest exposure, narrowing to 2 feet in the southeast pit. The vein can be traced 300 feet northwest of these workings, and shows up again about half a mile away, across a small valley. The workings consist of several narrow pits at intervals along the vein, the deepest being down 25 feet. Practically no dead rock has been removed, the pits extending only to the walls of the vein.

The barytes remaining around the workings is of a drab or greyish-white shade, rather than a good white. It is opaque, compact and massive, exhibiting a banded and often modified mammillary structure. The various stages of deposition on the vein are well shown by conspicuous partings parallel to the walls, such partings usually being characterized by crested barytes. A further characteristic of such partings is the frequent presence upon them of films of elaterite—a black, asphalt-like, hydrocarbon mineral, which often fills the spaces between the crested barytes plates. Such material is, of course, highly undesirable, and renders the barytes containing it quite unfit for grinding without some process of cleaning. The chief other impurity visible in the ore is calcite, which occurs usually as small, isolated crystals.

The following analysis of a grab sample, taken from the old stock pile near the main pit, was made in the Mines Branch laboratory:—

| | |
|---|---|
| Barium sulphate | 92·13 |
| Strontium sulphate | 6·20 |
| Calcium carbonate | 1·60 |

A representative sample of the barytes from this deposit, ground to pass 200 mesh, unbleached, and tested for colour against a standard sample of prime white, paint barytes, proved to possess a drab grey (putty) colour.

The deposit, on account of the off-colour grade of the ore and the narrowness of the vein, possesses no particular economic importance.

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[1] Guide Book No. 2, International Geological Congress, 1913, p. 128.

### Township of Oso

*Concession I, lot 25.*—Lies 5 miles northwest of Sharbot Lake station, on the Kingston and Pembroke branch of the Canadian Pacific railway. A nearer shipping point would be Lillie's Mill siding, on the same line, about 3 miles southeast of the deposit. The owner of the property is John Crawford, Oso P.O., Ont. A road passes within 100 feet of the workings.

The only work done on this property was conducted about the year 1908, when a Mr. Rogers ran an open cut 100 feet long into the west side of a low ridge traversed by several narrow and parallel veins of barytes. The widest of these veins does not exceed 3 feet, the average width being much less, and they all occur in close proximity to one another, being possibly stringers from a single lead in depth. The strike is almost due east. The open cut is 20 feet deep at its inner end, and averages 6 feet wide.

The barytes occurs on well-defined, vertical veins, between walls of brown, medium- to fine-grained dolomitic limestone. Calcite, in well-developed scalenohedral crystals, was first deposited on the walls, followed by the barytes. The barytes breaks away readily from the walls, but is difficult to separate from the attached calcite, which often penetrates quite deeply into it. The barytes is of the massive, opaque variety, cream to light pink in colour, and with partially developed platy structure parallel to the growth planes. Deposition has taken place in one phase, since there are no partings in the ore paralleling the walls, as in many of the barytes deposits of this region, and has not succeeded in completely filling the vein fissures. Irregular, narrow open spaces mark the middle of the veins, and are lined with crested barytes. Fluorite, in well-formed, green crystals, has been deposited upon the crested barytes.

The large amount of calcite and fluorite, so intimately associated with the barytes as to make cobbing impracticable, would render concentration of the ore necessary. There does not appear to be a large enough body of ore present, however, to justify further development.

Barytes is reported to occur, also, on the east half of lot 20 in the same concession. A small amount of development work is stated to have been conducted about 40 years ago, but no shipments took place.

### Township of Portland

*Concession VIII, lot 5; concession IX, lot 5.*—A small deposit of barytes was opened up on these lots in 1917, but no ore was shipped. The occurrence lies 2 miles northeast of Hartington station, on the Kingston and Pembroke branch of the Canadian Pacific railway, on property owned by Ernest Botting, of Hartington.

A small pit, 15 feet deep, has been opened on a deposit of barytes occupying a faulted zone in Ordovician limestone. The deposit strikes northeast and has no well-defined walls; its apparent width is about 6 feet, but the exposures are insufficient to indicate exactly its lateral extent. The pit has exposed the lead for about 12 feet; outside of this, any further continuation of the deposit is concealed beneath hillside drift to the north, and swampy ground to the south.

The barytes occurs as the cementing material of brecciated, blue-grey Ordovician limestone, fragments of which are present in large quantities in the deposit. Small stringers of barytes, also, strike off from the main

body into the enclosing limestone. Large, fretted crystals of white calcite are common, enclosed in the barytes vein matter, and free crystals of calcite often encrust the tabular crystals of crested barytes on parting planes. The barytes itself is massive, with a faint approach to platy structure parallel to the planes of growth; it is opaque and creamy white in colour.

A sample of selected material from the stock pile, analysed in the Mines Branch laboratory, yielded:—

| | |
|---|---|
| Barium sulphate | 89·27 |
| Strontium sulphate | 4·90 |
| Calcium carbonate | 5·36 |

A representative sample of the barytes, ground to pass 200 mesh, unbleached, and tested for colour against a standard sample of prime white, paint barytes, showed faintly greyish.

Insufficient work has been done to indicate the extent of this ore-body, which possibly may carry a cleaner grade of ore in depth. The brecciated zone exposed at the surface, carries far too much foreign matter in the shape of country rock and calcite, to yield even a cobbing ore.

The existence of a major fault at this point, with a considerable downthrow to the west, is evidenced by the outcropping of granite gneiss a short distance east of the barytes and at approximately the same level; while on the west side, a considerable thickness of Palæozoic rocks is exposed along the road leading to the property.

## Lanark County

### Township of Bathurst

*Concession VI, lot 12, E.½.*—This property is 1½ mile north of Bathurst station, on the main line of the Canadian Pacific railway, and is owned by James Palmer, of Perth, Ont.

A little development work was carried out in 1917 by an American syndicate; and a shallow pit, 30 feet long, was opened along the deposit. This consists of an anastomosing system of narrow, vertical barytes stringers, comprised within a vein zone about 10 feet wide. The individual stringers attain a maximum width of 18 inches. The strike of the deposit is approximately east and west, and other outcrops occur over a distance of 1,000 yards. At none of these, however, does the deposit show up more thoroughly than at the point of attack, and none of them have been worked.

The barytes is clean, and unmixed with other minerals. It is of the soft type, opaque, massive, and with partially developed platy structure. The colour of the ore is not uniform, pink and white, or grey barytes alternating with each other. The general run-of-mine, therefore, would represent rather off-colour mineral.

The exposures are insufficient to show clearly the geologic associations. The barytes appears to be confined to a band of altered, dark, basic rock, enclosed in partially kaolinized gneiss. The barytes stringers occur both in the mass of the basic rock, and on its contact with the gneiss. The dark rock bears more resemblance to a pyroxenite member of the Grenville series than to a dike, and the barytes has probably been deposited on a zone of fracturing due to faulting.

The deposit passes under a swamp a short distance east of the pit, and outcrops again several hundred feet farther on, alongside the road bounding the property. No stripping has been carried out to the west of the pit.

While extending for a considerable distance along the strike, the deposit does not appear to attain any considerable width, and the narrowness of the individual barytes stringers involve the removal of much dead rock. In addition, the bulk of the ore would probably yield an off-colour product. An analysis of a representative sample of the ore in the stock pile, and analysed in the Mines Branch laboratory, yielded:—

| | |
|---|---|
| Barium sulphate | 93·42 |
| Strontium sulphate | 4·10 |
| Calcium sulphate | 1·40 |

A representative sample of the barytes from this deposit, ground to pass 200 mesh, unbleached, and tested for colour against a standard sample of prime white, paint barytes, showed a pronounced pink shade.

#### Township of Lavant

*Concession VIII, lot 20*.—Situated 3 miles from Clyde Forks station, on the Kingston and Pembroke branch of the Canadian Pacific railway. A bush road leads from Clyde Forks to the property, which lies in rather rough, hilly country. There is a good down grade from the deposit to the railway.

The property is owned by T. B. Caldwell, of Perth, Ont., who in 1919 carried out a small amount of development work in the shape of stripping and sinking a small pit, 15 feet deep, midway along the outcrop of the vein. This represents all the work performed on the deposit. One car of barytes ore is reported as shipped to the United States.

The deposit of barytes consists of a single vein, which has been exposed by stripping for a distance of 150 feet. The strike of the vein is northwest. and the apparent dip 30° northeast. The maximum width, as disclosed in the open pit, is 5 feet. The lead occurs near the crest of a ridge rising to a considerable height above a wide valley. There is little overburden, the rocks being well exposed for some distance around the deposit. The course of the lead is obliquely up the slope, the upper portion of the vein showing up in the face of a cliff. The vein widens as it descends this face, and attains its greatest width on a shoulder of the ridge immediately below it.

The barytes is of the hard crystalline variety, is medium- to coarse-grained, and semi-translucent. It thus differs radically from the soft, opaque type of the other deposits in this region. The bulk of the ore is white with a slight bluish or grey tinge.

The deposit is remarkable for the amount and variety of the sulphide minerals it carries. These are present in some amount practically throughout the vein, but are especially abundant in certain portions of it. In the bottom of the pit, barytes gives way almost completely to these metallics, mixed to some extent with quartz. Much of the surface barytes along the outcrop is stained green or blue by the oxidation products of the copper minerals present. The principal sulphides present are tetrahedrite, stibnite, bornite, chalcopyrite, and pyrite. The oxidation products of these minerals are chiefly azurite, malachite, and valentinite. The above

minerals occur in such amount throughout the deposit that relatively little barytes can be found entirely free of them. From the character of the vein in the bottom of the pit, it seems likely that barytes may prove in depth to occur merely as gangue for the sulphide minerals mentioned. An assay of a sample of these sulphides, made in the Mines Branch laboratory, showed:—

| | |
|---|---|
| Gold | Trace |
| Silver | 54·20 ounces per ton |

Analysis of a representative sample of the barytes, made in the Mines Branch laboratory, yielded:—

| | |
|---|---|
| Barium sulphate | 96·46 |
| Strontium sulphate | 0·80 |
| Calcium carbonate | 1·78 |

A representative sample of the barytes from this deposit, ground to pass 200 mesh, unbleached, and tested for colour against a standard sample of prime white, paint barytes, showed a decided blue-grey cast.

The vein occurs in crystalline, dolomitic limestone, which is slightly impregnated with sulphides adjacent to the walls. Gneiss, cut by pegmatite stringers, caps the limestone on the top of the ridge. No intrusive rock is evident in direct proximity to the vein, but pegmatite dikes also cut the limestone. It is doubtful, however, if such dikes are connected genetically with the barytes.

There is no mining plant of any description on the property.

A small sample of the barytes ore from this deposit was sent to the Mines Branch Ore Dressing laboratory, in 1919, for test, and the results of the work are given in Mines Branch Summary Report for 1919, p. 86. The sample consisted of barytes relatively low in disseminated sulphides, (chiefly argentiferous tetrahedrite), and contained also a little malachite and azurite: it showed on analysis:—

| | |
|---|---|
| Barium sulphate | 96·25 per cent |
| Copper | 0·52 " |
| Silver | 1·80 oz. per ton. |
| Antimony | Present |
| Arsenic | Present |

Tests were run on the sample to determine if it would be possible to recover the silver and copper, and at the same time produce a clean, high grade barytes, as tails.

Four flotation tests were made on the material ground to pass 100 mesh, and floated in a Janney flotation machine. As a result of these tests, the following conclusions were reached:—

1. The barytes produced as tails is clean and white and runs 97·75 per cent barium sulphate.

2. The recovery of the copper is approximately 80 per cent.

3. The recovery of the silver is approximately 50 per cent.

4. The sample was too small to enable conclusive results to be obtained.

#### Township of North Burgess

*Concession X, lot 20.*—Situated about 5 miles south of Bathurst station, on the main line of the Canadian Pacific railway. Shipments, however, may be made from a siding distant about 3 miles. The property is owned by Thomas Farrell, R.R. 3, Perth, Ont.

A few shallow openings were made on the property during 1918, and the deposit was traced over 1,000 feet. No shipments appear to have been made. Recently (December 1920) further development work has been undertaken by H. C. Bellew, of Montreal.

The barytes occurs as a single vein, striking northwest, and having a maximum width, as exposed in the surface pits, of about 2 feet. The vein traverses granite gneiss, and has a vertical dip. The ore is of the soft variety, massive, with an approach to platy structure, and of a prevailing light cream colour. Crystallized, crested barytes is common in druses. No mineral impurities of any kind were noticed at any of the exposures.

An analysis of a sample made up of material taken from the ore piles at the various openings on the vein, and analysed in the Mines Branch laboratory, showed:—

| | |
|---|---|
| Barium sulphate | 95·26 |
| Strontium sulphate | 4·00 |

A representative sample of the barytes from this deposit, ground to pass 200 mesh, unbleached, and tested for colour against a standard sample of prime white, paint barytes, proved barely distinguishable from the standard.

While the material is of good quality, the narrowness of the vein hardly renders it likely that the deposit will prove of economic importance.

## Leeds County

#### Township of Bastard

*Concession X, lot 24.*—According to R. W. Ells,[1] barytes occurs on this lot and was worked many years ago. The vein is stated to extend for at least ¼ mile, and to range from 1 to 2 feet in width. The present owner of the property states that he has no knowledge of any deposit or workings on this lot, but that a vein of barytes was encountered in a ditch on the roadside about a mile distant.

### Western Ontario

## Thunder Bay District

#### McKellar Island

Barytes was formerly mined here on a considerable scale, the chief operator being the United States Baryta Company, of Cleveland, Ohio.

According to E. D. Ingall[2], the barytes occurs in the form of a "rib of considerable thickness of clear baryta" in a 60-foot vein of quartz and calcite. The deposit was discovered in 1869, by the McKellar Brothers, and development work was undertaken a few years later. The principal

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[1] Geol. Surv. Can., Vol. XIII, 1900, p. 138A.
[2] Geol. Surv. Can., Ann. Rep., Vol. III, 1887-8, Part II, p. 40H; Vol. V, Part II, 1890-1, p. 106S.

vein is a large one, and consists of coarsely crystalline calcite and barytes; the two minerals occurring, for the most part, as distinct bands or ribs, though in certain parts of the deposit they are intimately mixed. A small amount of quartz is associated with the calcite and barytes, and sulphides—zinc blende, galena, and pyrites—occur as bands in the ore.

Besides the main vein, which is about 60 feet wide on the south side of the island, there are numerous narrow stringers in the country rock adjacent to it on the west side. It is on these stringers that the greatest amount of development work has taken place.

The enclosing rock is a dark green, coarse-grained trap, which forms the entire island. The latter measures only 8 or 9 chains in diameter, and is evidently part of the same dike that appears farther west, on Thompson's island.

Argentiferous blende appears to have been the principal silver-bearing mineral, but did not prove to occur in paying quantity.

During 1886, the band of barytes on the east side of the main vein was worked open cut; and the ore, hand picked to remove calcite and quartz, was shipped to the United States.

The last mining here appears to have taken place in 1894, when the Duluth Barytes Company shipped 500 tons of ore.

Barytes is a common gangue mineral, also, in the silver bearing veins on adjacent islands—e.g., Thompson, Spar, Jarvis, and Victoria islands.

QUEBEC

## Hull County

### Township of Hull

*Range X, lot 7.*—This property lies on the east side of the Gatineau river, about 5 miles by road from Ironside station, on the Gatineau Valley branch of the Canadian Pacific railway.

The property was worked a number of years ago, and an open pit was carried along the vein for a distance of 350 feet. This opening averages 3 to 4 feet wide (the width of the vein between walls) and is stated to be 60 feet deep. The last work was conducted about 1900, by the Canada Paint Company, of Montreal, who shipped a considerable tonnage of ore.

The deposit consists of a single vertical vein, striking north 20° west, and averaging 3 feet in width. The vein traverses Grenville crystalline limestone. It appears to have been widest at the south end, and can be seen pinching to a mere stringer at the north end of the pit. The workings are now full of water, hence it is impossible to examine them.

From an examination of the waste dumps, the ore consists of soft, massive barytes, of a good white colour. It is somewhat intimately mixed with pale green fluorite, and a considerable amount of mixed ore appears to have been discarded. An analysis of selected barytes from the dump, analysed in the Mines Branch laboratory, yielded:—

| | |
|---|---|
| Barium sulphate | 71·96 |
| Strontium sulphate | 2·70 |
| Calcium sulphate | 14·57 |
| Calcium carbonate | 9·46 |

A representative sample of the barytes from this deposit, ground to pass 200 mesh, unbleached, and tested for colour against a standard sample of prime white, paint barytes, showed just perceptibly greyer than the standard.

Barytes is reported to occur, also, on range XI, lot 3, and range XII, lot 4, of Hull township. No work has been done on these properties, and they do not appear to possess economic importance.

#### Township of Templeton

*Range VI, lot 11 E.½.*—Owned by Arthur Berrea, of Perkins Mills, Que. The property lies 4 miles from East Templeton station, on the North Shore line of the Canadian Pacific railway, and 1½ mile east of the East Templeton-Perkins Mills road.

The deposit is of no economic importance. A small prospect pit, opened many years ago, discloses a 12-inch vein of soft white, massive barytes, striking north 25° west, between walls of silicated, Grenville crystalline limestone. The vein can be traced for a distance of only 25 feet.

Zinc blende occurs in appreciable amount in certain portions of the vein; no other accessory minerals were noticed.

*Range XII, lot 12.*—This locality may be mentioned as being that which yields the variety of barytes termed by Lacroix "Michel-Lévyte," and supposed by him to crystallize in the monoclinic system. Dana has since shown that the material agrees with ordinary barytes in its optical properties, but possesses certain peculiarities in cleavage which may be due to pressure.[1] The deposit possesses no economic importance.

*Range XIII, lot 13 N.½.* A narrow vein of coarsely crystalline, clear, blue barytes occurs on this lot, near Little Dam lake. The deposit occurs at the contact of pyroxenite and crystalline limestone, is only a few feet wide, and of unascertained length. It does not appear to be of economic importance, but is remarkable for the fact that considerable quantities of rutile (oxide of titanium) occur both in the barytes and in the calcite bordering the vein.

A small prospect pit has been opened on the lead, but no attempt to mine the barytes has ever been made.

### Labelle County

#### Township of Buckingham

*Range IV, lot 21.*—Property of Henry Gorman, Buckingham, Que. The nearest rail point is Angers station, on the North Shore line of the Canadian Pacific railway, and 5 miles from the property.

Many years ago, operations were conducted here for galena, which occurs in appreciable amount in certain portions of the deposit. A number of pits were opened, following individual veins, and at one point a 40-foot shaft was sunk. Nothing further has been done since that time, and no barytes appears ever to have been shipped.

The barytes occurs on a series of at least six more or less parallel veins traversing Grenville crystalline limestone. The total width of vein zone is about 100 feet, and the length, as indicated by the workings, 250 feet. The veins are narrow, and seldom exceed 12 inches: possibly the

[1] Geol. Surv. Can., Ann. Rep., Vol. IV, 1888-9, p. 66T.

worked-out portions were wider, since the pits are as much as 5 feet across, in places. Most of the work done was performed on what appears to have been the main lead; it is on the southeasterly outcrop of this lead that the shaft was sunk, and the largest of the open pits are also situated upon it.

The barytes is of the soft, massive type, and is creamy white in colour. It carries considerable galena, both as isolated crystals and as bunches of massive ore. Zinc blende is also present in less amount. A grab sample from the ore piles at the various openings, analysed in the Mines Branch laboratory, showed:—

| | |
|---|---|
| Barium sulphate | 93·51 |
| Strontium sulphate | 1·00 |
| Calcium carbonate | 3·57 |

A representative sample of barytes from this deposit, ground to pass 200 mesh, unbleached, and tested for colour against a standard sample of prime white, paint barytes, showed a strong drab (putty) colour.

The distance between individual veins, and their relative narrowness, as well as the amount of sulphide minerals present in the ore, combine to render this deposit of little economic importance.

## Pontiac County

### Township of Onslow

*Range III, lot 12.*—Situated close to the village of Quyon, one mile from Quyon station, on the Pontiac branch of the Canadian Pacific railway. The property is owned by Mrs. Wright, Quyon, Que.

A few small pits have been opened on a series of narrow, parallel veins of barytes traversing Ordovician limestone. The vein zone is narrow, and the widest vein is not over 12 inches between walls. The trend of the deposit is northwest, and outcrops occur for a distance of 500 feet. For the greater part, the deposit consists of mere stringers, and the occurrence is not of economic value.

The barytes is soft and massive, and exhibits zonal banding: the successive layers ranging in colour from white to pink and brick red. Fluorite, of a pale green shade, is present in considerable amount in the wider portions of the veins, and forms an incrustation upon the barytes.

A representative sample, taken from the various outcrops, and freed of fluorite, analysed in the Mines Branch laboratory, yielded:—

| | |
|---|---|
| Barium sulphate | 92·59 |
| Strontium sulphate | 1·50 |
| Calcium sulphate | 4·50 |

A representative sample of the barytes from this deposit, ground to pass 200 mesh, unbleached, and tested for colour against a standard sample of prime white, paint barytes, exhibited a very pronounced pink colour.

### Minor Occurrences

The following additional localities at which barytes is reported to occur, include those listed in Memoir 74 of the Geological Survey, pp. 38-40. As far as known, none of these occurrences possess any present economic importance:—

BRITISH COLUMBIA

*Grand Forks mining division.*—Masses of large, tabular, yellow crystals of barytes occur at the Rock Candy fluorite mine, on Kennedy creek.

*Kamloops mining division.*—With galena at Adams lake. (Geol. Surv. Can., Vol. VII, p. 21A.).

*Quesnel mining division.*—In lignite on Horsefly river. (Geol. Surv. Can., Vol. VII, p. 99A.).

*Slocan City mining division.*—Occurs as a gangue mineral at the Ottawa mine, and on the Calumet, Hekla, and Myrtle claims.

*Slocan mining division.*—Is found on the Robin claim near Standard river.

*Vancouver island.*—Occurs in a vein north of Cowichan lake; as a gangue mineral at the Mount Sicker copper mine, and at the Tyee mine.

MANITOBA

*Lake Winnipeg.*—Barytes occurs in veins in serpentine on Pipestone island. (Geol. Surv. Can., Vol. XI, p. 54G.).

ONTARIO

White and grey, massive barytes is stated to occur in Ordovician limestone on concession VII, lot 27, of the township of Huntley, Carleton county. (Geol. Surv. Can., Vol. XII, 1899, p. 19R.). This locality is probably given in error, for the owner states that he has no knowledge of any barytes occurring on the property.

Barytes occurs at several of the fluorite mines in the Madoc area, Hastings county. It does not, however, usually occur in sufficient quantity to be saved as a by-product. On lot 10, concession XII, township of Huntingdon, (Blakeley mine), barytes, baryto-celestite, and fluorite, occur associated together on a 5-foot vein. An interesting occurrence of stalactitic barytes from one of the fluorite mines of this district is described by T. L. Walker.[1]

A small shipment of a mixed ore, consisting of fluorite, calcite, and barytes, from the west half of lot 1, concession I of the township of Madoc, was sent to the Mines Branch Ore Dressing laboratory for test, in 1919. The results of the test conducted on this material are given in Mines Branch Summary Report for 1919, pp. 71-3.

The ore was found to consist of:—

| | | |
|---|---|---|
| Barytes | 4·40 | per cent |
| Fluorite | 48·35 | " |
| Calcite | 40·00 | " |
| Silica | 3·10 | " |
| Alumina and iron oxide | 1·60 | " |

The test was conducted with the objective of making three products, barytes, fluorite, and calcite, and concentration was effected by tabling

[1] American Mineralogist, Vol. IV, p. 79.

on a Wilfley table. As a result of the work, the following conclusions were arrived at:—

1. To effect a good separation, and obtain good products, the ore will have to be ground to about 80 mesh.

2. A wet ball mill should be used to grind the feed for the table to —80 mesh, in order to avoid heavy slimes loss.

3. If the slimes loss could be kept down to 10 per cent, the following recoveries and grades of products should be obtainable:—

| | Recovery per cent | Grade per cent |
|---|---|---|
| Barytes | 75·5 | 81·9 |
| Fluorite | 65·2 | 74·8 |
| Calcite | 63·7 | 59·2 |

The ore treated, is reported to be considerably lower in barytes than the average of the deposit, in which case a better grade of barytes should be obtainable in actual practice.

*Carleton county.*—Township of March, concession IV, lot 21.

*Frontenac county.*—On Dog lake, township of Storrington.

*Lanark county.*—Township of North Burgess, concession IX, lot 4; township of Lavant, concession I, lot 22; township of Ramsay, concession IV; township of Pakenham, concession XI, lot 3.

*Nipissing district.*—Red crystals of barytes occur on Iron island, in lake Nipissing.

*Peterborough county.*—In Dummer and Galway townships.

*Victoria county.*—In Somerville township.

## QUEBEC

*Bonaventure county.*—Port Daniel, and on streams flowing into Gaspé basin, in veins in limestone.

## WITHERITE

No commercial deposits of witherite—the natural barium carbonate—are known to occur in Canada.

Only two occurrences of the mineral are recorded in R. A. A. Johnston's List of Canadian Mineral Occurrences[1]; both are probably of only mineralogic interest.

One of the localities given is in Nepean township, Carleton county, Ontario. The other is the Porcupine mine, in Gillies township, Thunder Bay district, Ontario; there, witherite is said to occur as a gangue mineral in a silver bearing vein.

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[1] Geol. Surv. Can., Memoir 74, 1915, p. 238.

# CHAPTER III

## SOURCES AND USES OF BARIUM

The minerals barytes (barium sulphate) and witherite (barium carbonate) are the only important known sources of the element barium. Witherite is the less common of the two minerals, commercial deposits being confined at present to Great Britain and Germany. Barytes, in addition to being utilized in the finely ground state in a number of products, such as paints, paper, rubber goods, linoleum, etc., forms the raw material for the manufacture of lithopone and various barium chemicals. Metallic barium is of no present industrial importance.

### Barytes

Barytes, sometimes called "barite," "heavy spar," "cawk" or "tiff," when pure, is barium sulphate ($BaSO_4$) and contains 65·7 per cent of baryta or barium oxide ($BaO$) and 34·3 per cent of sulphur trioxide ($SO_3$). Much of the crude barytes ore mined contains impurities in the shape of sulphate or carbonate of lime, silica, alumina, calcium fluoride, and strontium sulphate. In addition, sulphide minerals, such as galena, chalcopyrite, sphalerite, and pyrite, may also be present. The crude barytes of commerce commonly runs from 90 to 95 per cent of barium sulphate. The lithopone and barium chemical manufacturers impose penalties of so much per unit for each percentage below a stipulated grade. Ore running less than 90 per cent barium sulphate is not commonly acceptable to these industries, and in addition, a low maximum content of iron and alumina, lead, silica, and fluorite, is demanded.

Barytes is a widely distributed mineral, and economic barytes deposits are found in many countries. The foremost producers are the United States, Germany, and the United Kingdom, followed by Belgium, France, Italy, and Spain. Prior to the war, Germany had for many years led in the production of barytes, and as far as known, the German deposits probably rank as the most important in the world.

The available supply of crude barytes sufficiently pure to satisfy the trade specifications has up to the present been adequate to supply the demand, and concentration of low grade ores has seldom been resorted to. In Canada, concentration has been practised in the Lake Ainslie district, in Nova Scotia, and also in northern Ontario. The growing consumption of barytes, and the rapid depletion of known deposits would suggest that it may prove profitable at no very distant date to undertake the refining of lower grade barytes.

Barytes is a heavy, white, opaque or translucent mineral. Its specific gravity is about 4·5. It varies somewhat in hardness, the average being 3, or the same as calcite. It is brittle, and when well crystallized possesses prominent cleavage. The translucent varieties have vitreous to resinous and often pearly lustre. Much of the barytes ore of commerce is stained pink or brown by oxide of iron and has to undergo bleaching with sulphuric acid in order to render it white enough for certain trades. In the case of some off-colour barytes, however, the coloration is inherent and cannot readily be removed by bleaching.

In the trade,[1] two types of crude barytes are recognized, "hard crystalline," and "soft". The former possesses spathic character, and is hard and coherent, while the soft type has a milky appearance, and is more or less friable. The soft type is preferred for grinding, as it yields the best grade of ground barytes on account of its texture, and because impurities in it can more readily be dissolved and eliminated by treatment with acid. The hard variety, on the other hand, is employed in the manufacture of lithopone and barium chemicals.

Barytes is valuable in industry on account of its being a heavy, white, chemically inert, and relatively cheap mineral. The market price of crude barytes is largely dependent on the ease with which it can be ground, and that of ground barytes, on its colour, fineness, and chemical purity. For certain purposes, for instance where ground barytes is to be used as a filler, chemical purity is not so important, within reasonable limits, as the first two considerations.

The barytes of commerce is:—

1. *Crude barytes.*—The natural mineral as mined, or after it has been washed to remove clay or earth and, where necessary, picked or jigged to remove admixed rock.

2. *Ground barytes.*—The fine powder obtained by grinding the cleaned crude ore. Crude barytes that is of the required degree of whiteness, needs only to be ground fine. Much of the ore mined, however, is—as already mentioned—stained pink or brown by iron oxide, and requires to be bleached by means of sulphuric acid to yield a prime, white ground product. Ground barytes that is not pure white, enters the market as "off-colour" or "unbleached," and finds employment as a pigment in dark coloured paints, and as a filler in rubber goods, and heavy paper material such as Bristol board, playing cards, etc. Ground barytes that has undergone a bleaching process, is known as "prime white" or "floated" barytes. It is chiefly used as a pigment in white paints[2] and, as a filler in paper and rubber goods. Where a superfine white barytes is required, ground natural barytes is replaced by *blanc fixe* (precipitated barium sulphate). This is produced by precipitating barium sulphate from a solution of a barium salt, such as barium chloride, by means of a sulphate, usually salt cake, or by sulphuric acid. Blanc fixe, while identical, chemically, with pure natural barytes, differs from it in its physical properties.

The natural carbonate of barium (witherite) may be used to replace barytes for certain purposes; for instance, as an inert filler for rubber goods, and as raw material for the manufacture of barium chemicals. Witherite contains 77·6 per cent of barium oxide, has about the same hardness and specific gravity as barytes, but, unlike the latter, is readily decomposed by acids. The available supply of witherite is not large, and relatively little is used.

Celestite, the natural sulphate of strontium, closely resembles barytes in its general characteristics. It contains, when pure, 56·4 per cent of strontium oxide. Like barytes, it is insoluble in acids, and has the same hardness,

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[1] This refers to American practice.

[2] Barytes, when used in paints, is variously referred to as a pigment, extender, or filler. In the past, it has been somewhat discredited, owing to its having been sometimes employed as an adulterant of white lead; but later research has shown that it possesses properties that render it of decided value as a paint pigment. (See M. Toch, Chemistry and Technology of Paints, 2nd Edition, 1916, p. 112.)

but a slightly lower specific gravity — 3·9. Up to the present time, there has been little attempt to substitute celestite for barytes in the arts. Owing to the general similarity of the two materials, it appears probable that increasing amounts of celestite may be employed to replace barytes in various of the industries using the latter mineral. Celestite of domestic origin has been successfully employed to replace barytes in paint manufacture in Canada, and it is also considered suitable as a filler for rubber. The principal known deposits of celestite are in Sicily and Great Britain. Most of the celestite mined is converted into strontium hydrate, which is employed in the refining of beet sugar by the Scheibler process.

## Ground Barytes

The amount of ground barytes produced in the United States, in 1919, was 63,000 tons. This was an increase of about 9,000 tons over the 1915 production. In the same period, the amount of crude barytes consumed in the manufacture of barium chemicals rose from 10,000 tons to nearly 27,000 tons; and the amount of crude barytes used in the lithopone industry increased from 44,000 tons to 104,000 tons.

While lithopone and blanc fixe are finding increased demand for special uses, the relative cheapness of ground natural barytes will probably result in its continued employment in many lines of products. A sustained demand may also be anticipated for off-colour barytes for use in products not requiring a white pigment or filler.

### MANUFACTURE OF GROUND BARYTES

Various modifications of the method of preparing ground barytes are in use, depending on the character of the crude ore. The barytes occurring in residual clay in the Missouri and Georgia deposits in the United States, undergoes, for instance, a different preliminary treatment to the vein barytes of the English, German, and other similar deposits. The type of grinding machinery used, also, may differ, according to whether the ore is of the soft variety or is of hard crystalline type. Barytes that is white enough in its natural state to yield a prime white product, may require no bleaching, while, on the other hand, the off-colour barytes of certain deposits does not seem to respond to ordinary bleaching with sulphuric acid, and can only be marketed in the ground form as an off-colour grade.

It is necessary, therefore, for the successful operation of a barytes deposit, to have proper knowledge of the character of the ore, and of the uses for which it may be best suited. Otherwise, capital may be expended on the erection of a grinding plant to treat ore that, on account of its hardness and crystalline character, content of mineral impurities, off-colour cast, or for other reasons, either cannot be made to yield a ground product that will meet trade specifications, or can only be made to do so at an excessive cost. Producers of the best grade of ground barytes prefer soft barytes as raw material, while the harder crystalline ores are utilized principally as raw material in the manufacture of lithopone or of barium chemicals. Hard, crystalline barytes, may be made to yield a prime ground product if subjected to a lengthy grinding process, but the expense involved would be considerably greater than that involved in the grinding of soft ore. Crystalline ore, stained by iron oxide, does not respond to bleaching treatment as readily as the soft type.

In the case of the Missouri residual deposits, the lumps and masses of barytes, dug out of the clay, are spread out to dry. During drying, the adhering clay shrivels and cracks, so that it is readily loosened from the barytes. The ore is then shaken in a rattler to knock off the clay and screen out the fines. Mineral impurities in the shape of quartz, limonite, pyrite, etc., are removed by hand cobbing.[1]

Georgia barytes occurs in much the same way as the Missouri ore, and is cleaned of adhering clay by washing in log washers. The cleaned ore coming from the washers is sized through $\frac{1}{2}''$ and $\frac{3}{4}''$ screens; the overs passing to a picking belt, where rock, etc., is picked out, and the undersize conveyed to jigs. The mine-run material may range from 10 to 60 per cent barytes, and the cleaned, shipping product averages 90 to 96 per cent barytes.

Lode or vein barytes, under which head comes practically all the Canadian ore, does not, of course, require any preliminary washing treatment to remove clay or dirt. Vein deposits of barytes vary widely in their mineral constituents; in some cases, the barytes may be sufficiently free of mineral impurities to constitute a straight grinding ore, while in others, it may have to be subjected to some process of concentration. It depends largely on the nature of the impurities, colour of the ore, etc., whether concentration can be practised to advantage. In the case of an off-colour ore carrying up to 10 per cent of calcite, fluorite, and silica, it might be more advisable to grind the crude ore and market the product as an off-colour grade, or to ship it to the lithopone trade, than to attempt to remove the impurities and bleach the ground product. On the other hand, a good, white ore, carrying a percentage of sulphides, or an appreciable amount of silica, calcite, or country rock, might be profitably concentrated. The form in which the mineral impurities are present is also of decided importance in this connexion. An ore containing fragments of brecciated country rock, aggregates of galena, or other metallic minerals, inclusions of quartz, etc., may have a large part of these impurities removed by a preliminary rough crushing, with subsequent hand picking, and jigging. In other cases, the accessory minerals may be present in a finely divided form, disseminated throughout the ore, and may be removable only by an expensive concentration process.

Barytes ore that is not pure enough to grind in the crude or washed form, usually undergoes a rough crushing, preceded or followed by hand picking, and is then jigged to remove remaining admixed impurities. Barytes being a mineral of relatively low value, impure crude barytes that cannot be brought up to a barium sulphate content of about 90 per cent, by the above means, is of questionable value, since the cost of concentration by additional treatment would probably be prohibitive.

The grinding machines most generally used in the fine grinding of barytes are buhr mills—the grinding being wet. Usually, several sets of buhr stones, in series, are employed. German producers sometimes pass their barytes through as many as eleven sets of stones, but three or four sets is the more usual practice. Barytes may also be ground dry in buhrs, but the product is not of such good quality as the wet ground. Edge runner, or chaser mills, are often employed to grind the crushed crude barytes to a coarse powder for feeding to the buhrs.

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[1] W. M. Tarr, the Barite Deposits of Missouri, University of Missouri Studies, Vol. III, No. 1, p. 102.

In place of buhr stones, impact pulverizers and tube mills are sometimes used. There does not appear to be any data available as to the respective merits of these various types of grinders. In the case of one Canadian mill equipped with a pulverizer of the impact type, running on hard crystalline barytes, the ground product proved decidedly gritty, and far from uniform in mesh. Better results might possibly be obtained with this type of grinder on soft ore.

When wet grinding is practised, the fine pulp or slurry is run over classifying screens or into settling tanks, which effect a separation of any coarse particles. The finest, water-floated barytes is sent to the bleaching tanks, and the coarser product returns to the grinders. In dry grinding, passing the barytes through a sufficient number of buhr stones may effect a sufficiently fine product without any separation being required. Impact pulverizers are usually provided with an air separating device, which removes the barytes particles as soon as they are fine enough to be lifted; air floated barytes, however, is not considered of such good grade as water floated barytes.

If a prime white grade of barytes is required, it is necessary in most cases to subject the pulverized barytes to a bleaching process. However white the crude ore may be, it seldom yields a dead white powder, the product usually having a grey, pink, or yellowish cast. This coloration is sometimes "killed" by the addition of a small quantity of ultramarine, generally during the grinding. It was formerly the practice to bleach the barytes in the small lump or coarse sand form, before it underwent fine grinding. This course is still followed in some English mills, but in American practice, the bleaching is usually carried out after the barytes is pulverized.

Bleaching is carried out by means of sulphuric acid. The ground barytes is placed in lead lined tanks, equipped with steam coils, and dilute sulphuric acid is run in. The steam coils are perforated, permitting the passing of steam into the solution. After heating to boiling temperature for some hours, with stirring, (the time required for bleaching is dependent on the degree of discoloration of the crude barytes), the product is transferred to washing tanks, where it is thoroughly washed with water, and is afterwards dried. The dried product undergoes a final pulverizing to break up lumps, and is then ready for bagging.

The above is a general outline of the process through which crude barytes passes in the preparation of ground barytes for the trade. Depending on the character of the ore, various modifications of the steps described may be employed, and the procedure varies in different countries, and even in different mills in the same district. On the following pages are given flow sheets of barytes mills in Missouri and Georgia, U.S.A., and Shropshire, England.

Fig. 12 shows the system used in the mill of the Point Milling and Manufacturing Company, at Mineral Point, Missouri.[1] Fig. 13 shows the washing process employed at barytes mines in the Cartersville district,

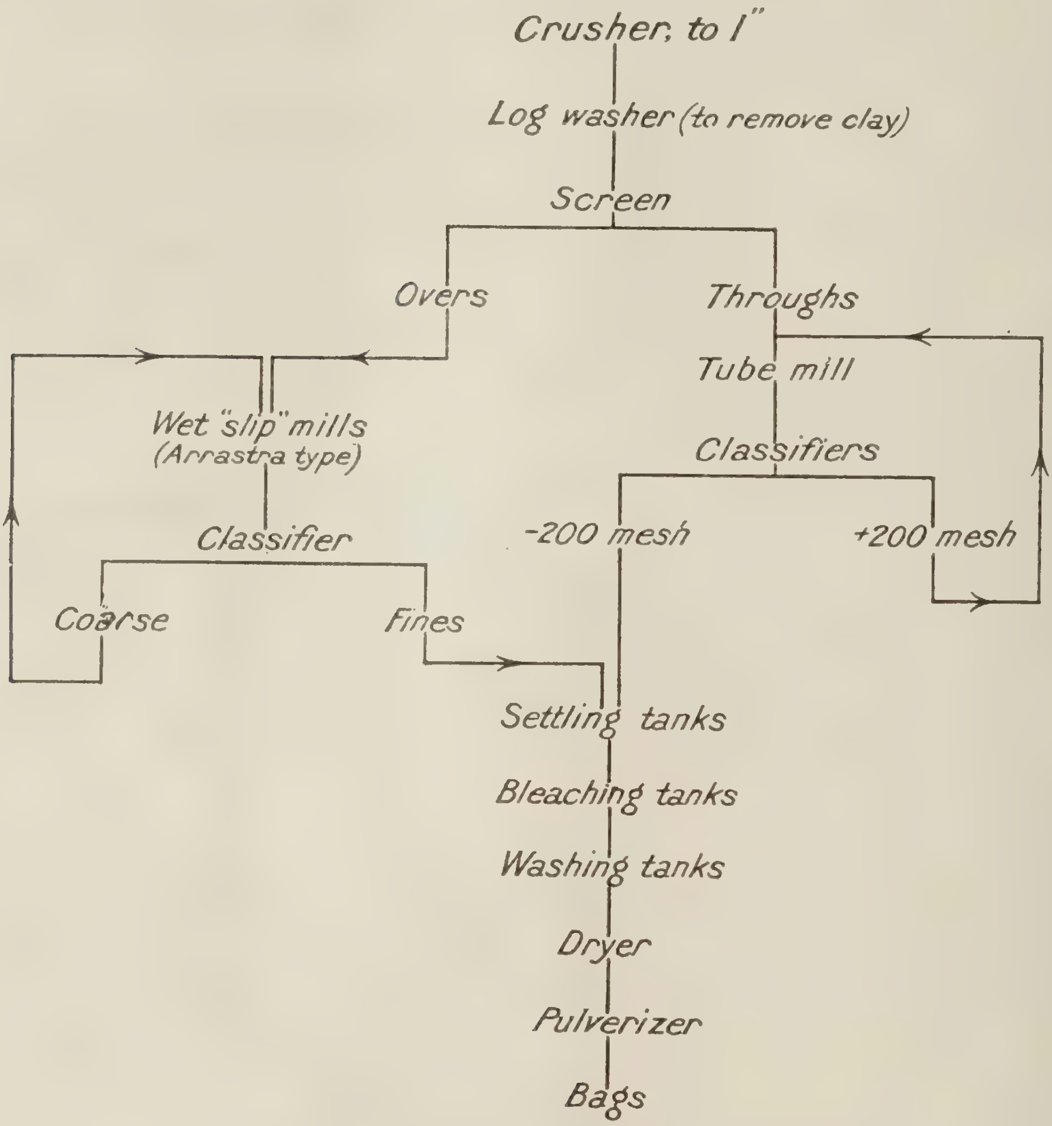


Fig. 12—Flow sheet of barytes grinding mill at Mineral Point, Missouri, U.S.A.

in Georgia, as well as the mill flow sheet of Thompson-Weinman and Company, Cartersville.[2] Fig. 14 is the flow sheet of the Cliff Dale washer and mill, Minsterley, Shropshire, England.[3]

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[1] The Barite Deposits of Missouri, University of Missouri Studies, Vol. III, No. 1, p. 103; also Bull. Amer. Inst. Min. Eng., No. 38, Feb. 1910, p. 109.

[2] Barytes Deposits of Georgia, Geol. Surv., Georgia, Bull. No. 36, 1920, p. 37.

[3] Special Reports on the Mineral Resources of Great Britain, Geol. Surv. Office, Vol. II, 1916, p. 63.

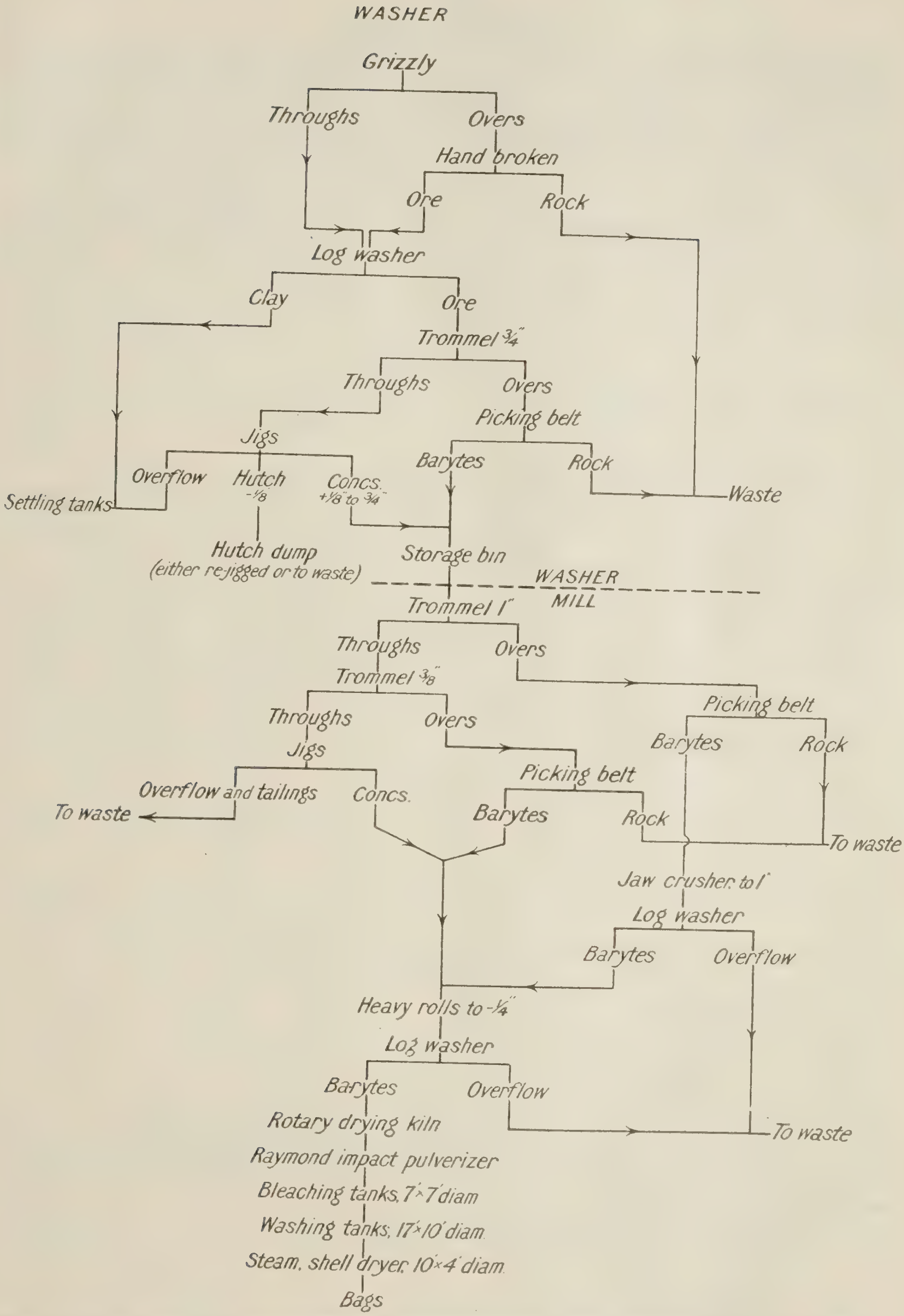


Fig. 13.—Flow sheet of barytes washing plant and grinding mill, Cartersville, Georgia, U.S.A.

PRICES AND COSTS

The figures given below are of interest as showing the average cost of mining crude barytes in the United States, in 1919, as well as the average cost of manufacturing ground barytes.[1]

Average cost of mining barytes and manufacturing ground barytes in the United States in 1919:—

| | Average total cost |
|---|---|
| Barytes | $ 7.14 per ton |
| Ground barytes | 19.25 " |

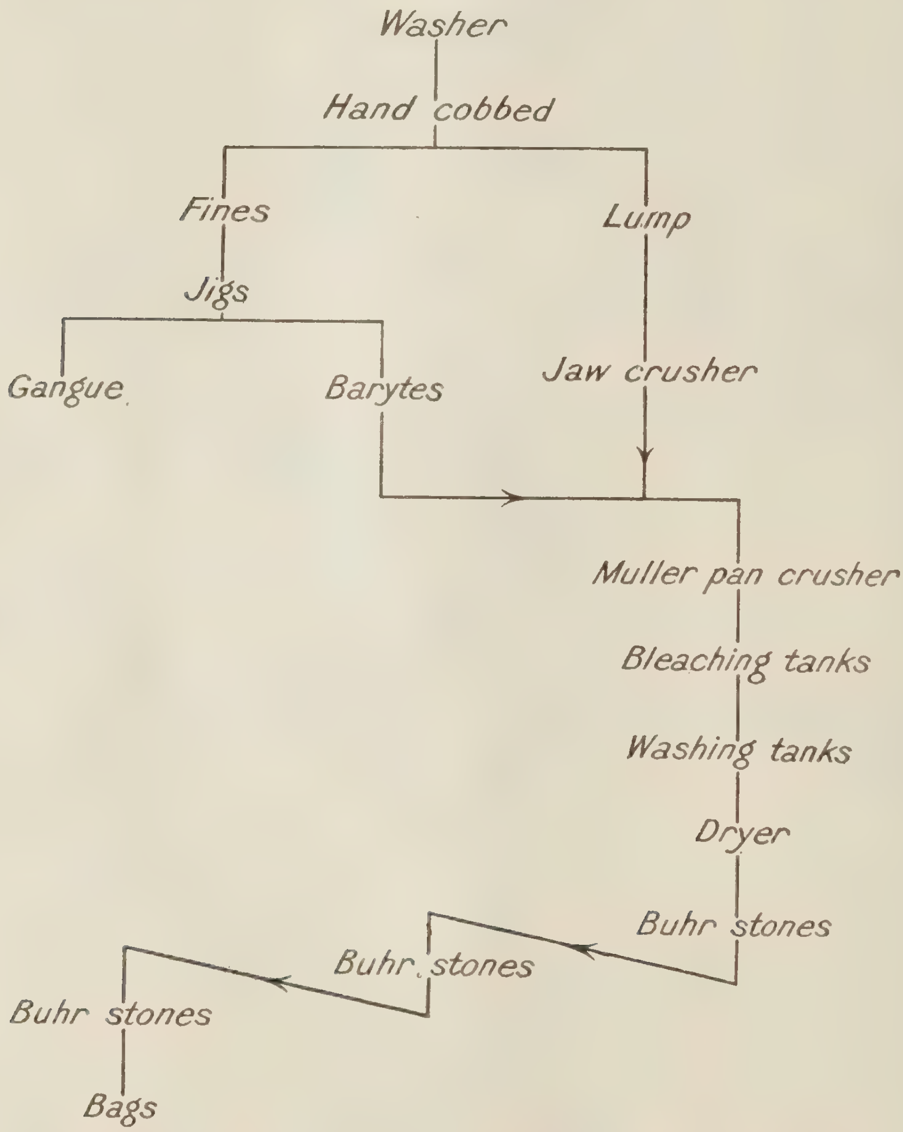


Fig. 14.—Flow sheet of barytes washer and mill, Shropshire, England.

In the manufacture of ground barytes, the average cost of raw material was estimated at $10.68 per ton, or 55·5 per cent, with $2.47 for labour, and $5.48 for overhead.

At the time of writing (February, 1921) the New York spot price of ground barytes is as under[2]:—

| | |
|---|---|
| Prime white | $25–27 per ton |
| Pure white, floated | 32–38 " |
| Off-colour | 20–28 " |

[1] For complete details as to percentage of the total cost due to the various items of cost, see Report No. 18. U.S. Tariff Commission, 1920.

[2] Oil, Paint and Drug Reporter, February 28th, 1921.

## Barium Chemical

The term "barium chemicals" is used to designate various barium salts or compounds which are manufactured by chemical processes from the barium minerals barytes and witherite. A number of such salts find employment in industry, the more important being the following:—

*Blanc fixe (artificial barium sulphate).*—Blanc fixe is prepared by precipitating barium sulphate from a solution of a soluble barium salt, such as barium chloride or barium sulphide, by means of a sulphate (sodium sulphate or salt cake) or sulphuric acid. It was formerly made from barium chloride and salt cake or sulphuric acid, but barium sulphide is now generally used. The latter salt yields a denser product than that produced from barium chloride, and, in addition, sodium sulphide is obtained as a by-product.

Blanc fixe is also obtained as a by-product in the manufacture of hydrogen peroxide from barium peroxide, by treatment with sulphuric acid.

For certain purposes, blanc fixe is precipitated from hot, concentrated solution; in this way, a crystalline product is obtained, which is a valuable base for the manufacture of brilliant colours.

Blanc fixe, or "permanent white," is the best grade of barium sulphate for pigment purposes, excelling the best ground barytes in whiteness and fineness, as well as in oil absorption. (Blanc fixe requires about twice as much oil to form a paste as does ground natural barytes). It is employed where a pure white pigment or filler is required, as in white paints, rubber goods, linoleum, oilcloth, and glazed paper. It is also used in lithographic inks, and as a base for lake colours. Under the name of "chemically pure barium sulphate," it is used as an indicator in X-ray photography.

Blanc fixe is marketed in the form of dry powder, and as a pulp. The latter contains about 30 per cent of water, and is used in paper and lithographic ink. The dry powder is used for pigment purposes.

*Barium carbonate.*—Barium carbonate is a white powder, obtained by treating a solution of barium sulphide with soda ash (sodium carbonate). Sodium sulphide is a by-product of the process.

Barium carbonate may also be prepared by passing carbon dioxide gas through a solution of barium sulphide.

While identical, chemically, with witherite (the natural barium carbonate), precipitated barium carbonate possesses physical properties that fit it for purposes for which the natural article cannot be substituted.

The largest uses for barium carbonate are in the ceramic industry: to prevent scumming on brick and tile, and in pottery glazes; also in the manufacture of optical glass. It is also employed as a pigment, to the extent of about 45 per cent, in flat wall paints, imparting a soft, velvety finish to the painted surface; in the enameling of ironware; and as raw material for making barium oxide, and peroxide. Barium carbonate has poisonous properties, and is employed as a constituent of rat poison.

*Barium chloride.*—This is a white salt that is fairly soluble in water. It crystallizes with two molecules of water, and is marketed in the crystalline or powdered form.

Barium chloride is usually made by roasting crude barytes with coal and calcium chloride. It may also be prepared by treating witherite (natural barium carbonate) with hydrochloric acid, or by adding calcium chloride or hydrochloric acid to a solution of barium sulphide.

Barium chloride may be used in the production of blanc fixe, though barium sulphide is the more commonly used salt. It is employed in the manufacture of colour lakes, as a mordant; in the purification of salt; as a water softener in boiler compounds; and in the leather and ceramic industries. It is also used in certain photographic chemicals; in medicine; as a chemical reagent in making sulphur determinations; and in rat and vermin poison. It may be noted that practically all barium salts have poisonous properties.

*Barium nitrate.*—A soluble, white salt, used principally in making barium peroxide. It is used to some extent in pyrotechny; for green flares and signal lights; explosive mixtures; and has certain medicinal uses.

Barium nitrate may be prepared by adding sodium nitrate (Chile saltpetre) to a solution of either barium chloride or barium sulphide. It is also formed when witherite (barium carbonate), barium oxide or barium hydroxide, is dissolved in nitric acid.

*Barium chromate.*—Known as lemon yellow, or ultramarine yellow, and used as a yellow pigment, and in safety matches. It is prepared by treating a solution of barium chloride or other soluble barium salt with sodium or potassium chromate.

*Barium monoxide.*—A white to yellowish powder, obtained as an intermediate product in the preparation of barium peroxide by the calcining of barium nitrate or carbonate.

Barium monoxide is used in certain varieties of optical glass. It is also used extensively in Europe, especially in Germany, in the refining of beet sugar.

*Barium hydroxide.*—An intermediate product in the refining of beet sugar, formed from barium monoxide by treatment with boiling water. When molasses is added to a hot solution of barium hydroxide, barium sucrate is formed; this is insoluble in hot water. On treatment with carbon dioxide gas, sugar and barium carbonate are formed. The latter is then reduced to barium monoxide in an electric furnace, so that the same material is used over and over again. Barium hydroxide has been supplanted to a great extent in sugar refining by strontium hydroxide. This has the advantage of possessing no toxic properties, while strontium carbonate is more readily reduced to the oxide than is barium carbonate.

Barium hydroxide may also be used to convert sulphate of potash into caustic potash, and is employed in refining animal and vegetable oils.

*Barium peroxide.*—Barium peroxide (binoxide or dioxide) is a grey powder, prepared from either barium nitrate or barium carbonate by calcination. Barium monoxide is formed, and is converted to barium peroxide by heating to 700°C, in a current of air or oxygen.

Barium peroxide finds its chief use in the manufacture of hydrogen peroxide, which is formed by treating the salt with dilute sulphuric acid, blanc fixe being obtained at the same time. In more modern practice,

phosphoric acid is employed in place of sulphuric acid. It is also employed in the production of oxygen by the Brin process, and as a bleaching agent, especially in the blanket and straw hat industries. It was used in the war in tracer bullets.

*Barium chlorate.*—Barium chlorate is used to a limited extent in pyrotechnics and in dyeing. It is a white powder, formed by the electrolysis of barium chloride.

*Barium phosphate.*—A fertilizer has been put on the American market in recent years under the name of "barium phosphate." The name is misleading, since the material is not phosphate of barium but a mixture of barium sulphide and apatite (phosphate of lime). The merits of this fertilizer have been investigated by the Rhode Island Agricultural Experiment Station, and are discussed in a bulletin of that Institution.[1]

*Barium sulphide.*—While not of any great technical importance in itself, barium sulphide is the intermediate compound from which the bulk of barium chemicals, and lithopone are made. With lime, it is used as a depilatory in the leather industry, and is also employed in vulcanizing, and in loading gutta percha.

Crude barium sulphide is made by roasting barytes with coal in a reduction furnace, and is commonly known as "black ash."

When a sodium salt is added to a solution of barium sulphide in the manufacture of barium chemicals, sodium sulphide is obtained as a by-product. This is a valuable product of the barium chemical industry and finds employment in the dye trade, in the preparation of sulphur black and other sulphur colours.

*Other barium chemicals.*—Other barium salts which, however, find much less extensive use in industry, include the following[2]:—

| | |
|---|---|
| Barium acetate | A chemical reagent. |
| Barium bromide | Used in manufacturing bromides. |
| Barium cyanide | Used in metallurgy. |
| Barium ethylsulphate | Employed in organic preparations. |
| Barium fluoride | A constituent of embalming fluids, enamels and antiseptic preparations. |
| Barium iodide | Used in medicine and in manufacturing iodides. |
| Barium manganate | An emerald green powder, employed as a pigment under the name of "manganese green" ("Rosenstiehl's green" or "Böttger's green"). |
| Barium sulphocyanate or sulphocyanide | Used in the manufacture of aluminium or potassium sulphocyanates. |

## MANUFACTURE OF BARIUM CHEMICALS

As raw material for the manufacture of barium chemicals, the best washed, soft barytes is preferred. The hard crystalline type, however, which is less suitable for use in the best grades of ground barytes, can also be used. The crude barytes is first crushed to pea size, and then mixed with pulverized coal, in the proportion of about one part of coal to four parts of barytes, by weight. The mixture is roasted for about four hours in a rotary reduction furnace, the barium sulphate being reduced

[1]Agricultural Experiment Station of the Rhode Island State College, Annual Fertilizer Bulletin, October, 1919.
[2]Condensed Chemical Dictionary, 1919.

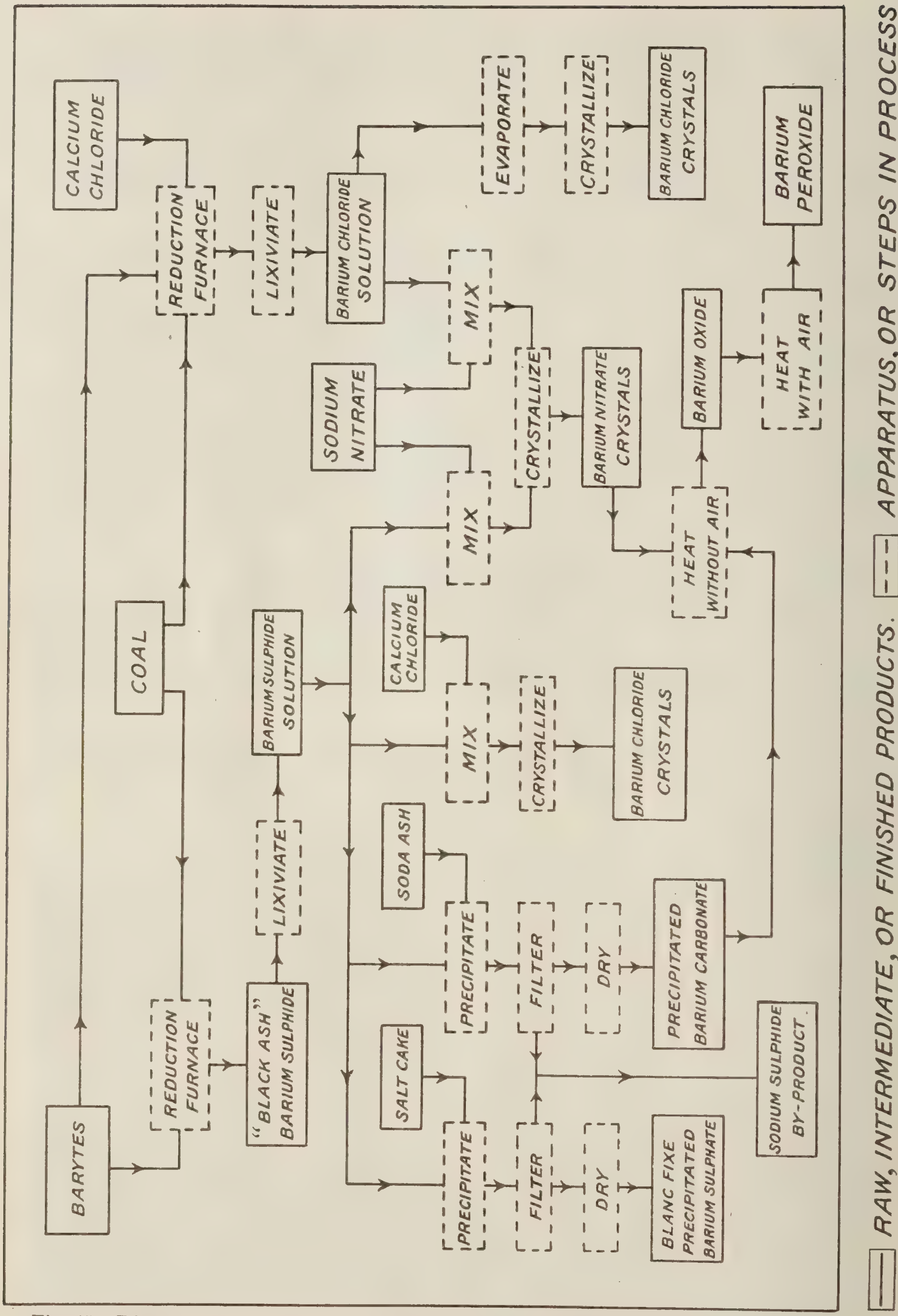


Fig. 15.—Diagram showing process of manufacture of barium chemicals, (from United States Tariff Commission Report No. 18.)

to barium sulphide. The crude barium sulphide (black ash), which contains about 70 per cent of barium sulphide, is lixiviated with hot water, and a solution of barium sulphide obtained. This solution is the initial product from which barium chemicals, also lithopone, are formed. The process of manufacture of various barium chemicals is illustrated in Fig. 15.

### PRICES AND COSTS

The price on the New York market of the more important barium compounds at the time of writing (February, 1921) is shown below[1]:—

| | | |
|---|---|---|
| Blanc fixe (pulp) | \$50 - 60 | per ton |
| " (dry) | 95 -100 | " |
| Barium chloride | 60 - 80 | " |
| " carbonate | 70 - 85 | " |
| " nitrate | $10\frac{1}{2}$- 11 | cents per pound |
| " chlorate | 40 - 45 | " " |
| " peroxide | $22\frac{1}{2}$- 25 | " " |

The total cost of manufacture of the four most important barium chemicals in the United States in 1919 was as follows[2]:—

| | Per pound |
|---|---|
| Barium carbonate | \$0·0316 |
| Barium chloride | 0·0539 |
| Barium peroxide | 0·197 |
| Blanc fixe | 0·0294 |

## Lithopone

Lithopone is a white powder consisting of a mixture of approximately 70 per cent of barium sulphate, and 30 per cent of zinc, calculated as zinc sulphide. The zinc is present as 26 to 28 per cent of zinc sulphide, and 1 to 3 per cent of zinc oxide.[3]

Many American manufacturers sell lithopone under a special trade name, such as Phonolith, Zincolith, Marbon white, Beckton white, etc.

Lithopone is used extensively as a white pigment in flat and enamel wall paints for interior use. It is also employed in large quantities as a filler or loader in rubber goods, paper, linoleum, oil cloth, and window shade cloth.

It is not suitable for use in exterior paints, owing to its property of darkening when exposed to bright sunlight. Lithopones that are claimed to be sunproof have, however, lately been placed on the market. It cannot be mixed with white lead, since the sulphur present results in the formation of dark coloured lead sulphide.

The consumption of lithopone in the United States, in 1919, was 73,000 tons, practically all of which was of domestic manufacture. Ten firms were engaged in the industry, and 80 per cent of the production came from the Atlantic coast district.

No lithopone is made in Canada.

### MANUFACTURE OF LITHOPONE

The basic raw materials in lithopone manufacture are crude barytes, coal or coke, zinc, and sulphuric acid. The initial step in the manufacture of lithopone is the production of a solution of barium sulphide and a

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[1] Oil, Paint and Drug Reporter, February 28, 1921.
[2] For percentage of total cost due to the various items of cost, see Report No. 18, U.S. Tariff Commission, 1920.
[3] American standard product. German lithopone comes on the market in three grades, containing, respectively, 11 to 18 per cent, 22 to 30 per cent, and 32 to 42 per cent of zinc sulphide.

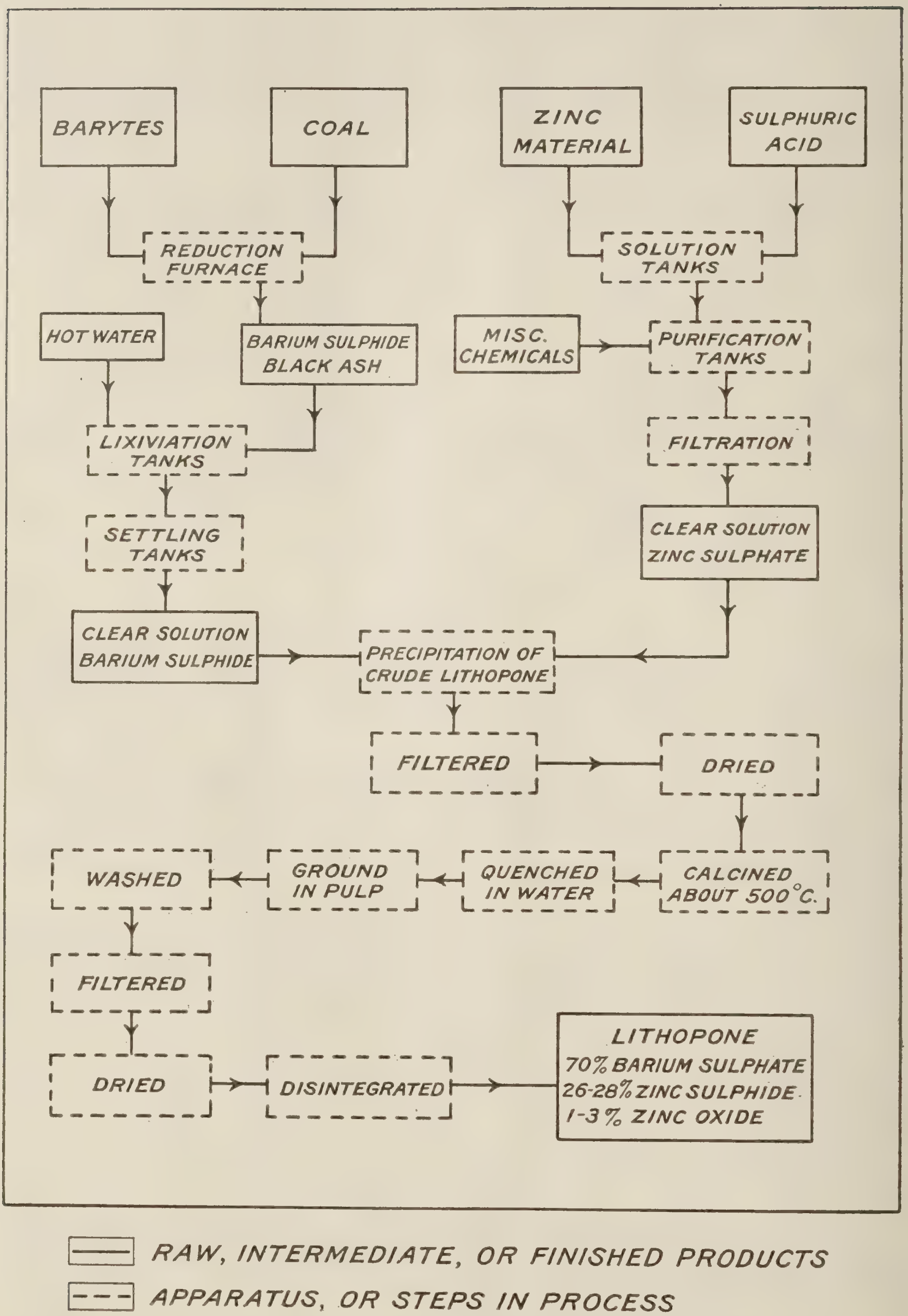


Fig. 16.—Diagram showing process of manufacture of lithopone. (From United States Tariff Commission Report No. 18.)

solution of zinc sulphate. Barium sulphide is prepared by roasting barytes with coal, as already described. The zinc sulphate solution is made by dissolving zinc (usually zinc scrap) in dilute sulphuric acid. As the zinc materials used generally contain impurities, it is necessary to purify the zinc sulphate solution, and this step is one of the most important in the process of manufacture. Chlorate of potash is the purifying agent usually employed. Crude lithopone is precipitated as a white powder from the purified zinc sulphate solution by adding to it a hot solution of barium sulphide. The crude lithopone is filtered out, dried, and calcined at about 500° C. in a muffle furnace. The hot, calcined material from the furnace is quenched in water, ground in pulp form, washed thoroughly to remove any soluble impurities, filtered, dried, and passed through a disintegrator. In some cases, the ground lithopone is air floated to insure a uniformly fine product. Fig. 16 shows the process of manufacture of lithopone.

### PRICE AND COST

The New York market price of lithopone at the time of writing (February, 1921) is 7 cents per pound.[1]

In 1919, the total unit cost of manufacture of lithopone in the United States was $0·0259 per pound.

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[1] Oil, Paint and Drug Reporter, February 28, 1921.

# PART II

# STRONTIUM

## CHAPTER I

## CELESTITE MINES AND OCCURRENCES

Only four occurrences of celestite of possible economic importance are known in Canada, all of them being in Ontario. The largest of these is situated in the township of Bagot, Renfrew county. This deposit is being exploited at the present time (November, 1920). The other occurrences are situated in the township of Lansdowne, Leeds county; township of Loughborough, Frontenac county; and township of Fitzroy, Carleton county.

With the exception of a small amount taken from the Lansdowne deposit many years ago, all of the celestite ever mined in Canada was obtained during 1919–20 from the deposit in Bagot township. The celestite of this occurrence contains about 15 per cent of barium sulphate. Several cars of hand cobbed ore have been shipped from this property to domestic paint works.

### ONTARIO

### Carleton County

#### Township of Fitzroy

*Concession VI, lot 21.*—This property is 1½ mile northeast of Galetta station, on the Ottawa–Parry Sound branch of the Grand Trunk railway. The distance by rail from Ottawa is 34 miles. The property is owned by Messrs. A. and M. Riddell, of Galetta.

In 1910, prospecting operations for galena were conducted here, and a shaft was sunk to a depth of 45 feet on a narrow lead in crystalline limestone. During mining operations, tin ore was reported to have been found, and the deposit was examined for the Department by L. H. Cole, of the Mines Branch, whose report appeared in Mines Branch Summary Report for 1910, p. 93. Assay of the samples showed that the ore carries no tin, and mining operations appear to have been abandoned soon after.

In 1921, on examining some of the samples of gangue minerals from this deposit, the writer noticed several large specimens consisting almost wholly of well crystallized celestite. The material appeared pure enough to warrant an examination of the property, which was visited in August, 1921. No further work appears to have been conducted since Mr. Cole's visit, and the small shaft being full of water, an examination of the deposit could not be made. No stripping has been carried out near the shaft, and no indications of the vein are visible on the surface.

Examination of the material on the dump showed it to contain a considerable quantity of celestite, and about one hundred pounds of fairly clean ore was collected from the surface. This included a single specimen of about 50 pounds weight, and consisting almost entirely of coarsely crystalline celestite. The presence of such a mass suggests the existence of a celestite body large enough to be considered of possible economic importance. An analysis of a representative sample of the clean celestite picked from the dump showed it to contain:—

| | |
|---|---|
| Strontium sulphate | 93·00 |
| Calcium carbonate | 1·30 |
| Oxides of iron and alumina | ·85 |

Most of the dump material consists of coarsely crystalline limestone, and vein calcite. The latter occurs in considerable amount, and often in the form of large crystals of scalenohedral habit, indicating a drusy character for the vein. Only traces of sulphides—zinc blende and chalcopyrite—were noticed, mostly as minute crystals on calcite.

The celestite occurs as a mass of rather loosely-interlocking crystals of tabular habit, and is generally white, to colourless. Occasionally, light blue and reddish shades prevail in the clear crystals. There appears to be little admixture of calcite or other foreign minerals with the celestite, and the analysis given above shows that the material is exceptionally pure.

According to L. H. Cole[1], the average thickness of the vein, as exposed in the shaft, is 2 feet. The shaft was put down vertical, and followed the vein for 20 feet, at which depth the lead flattens, and makes into the hanging-wall. A cross-cut driven from the bottom of the shaft, at 45 feet, picked up the vein at 10 feet from the shaft. This represents all the underground work performed. The vein is stated to possess a decidedly vuggy character, and a considerable amount of leaching by surface water appears to have taken place, since at 45 feet, where met by the cross-cut, the lead proved to contain much clay, mixed with pebbles and surface drift.

The country rock is Pre-Cambrian, crystalline limestone, containing siliceous zones, and cut by bands of greyish granite. A narrow band of granite traverses the limestone close to the shaft, but the surface relations would not indicate any connexion between the vein and the intrusive. The vein has, more probably, originated upon a line of structural dislocation in the limestone, although no direct evidence of faulting was noticed. The celestite has, probably, been deposited by ascending solutions from a deep seated source rather than concentrated by leaching from the enclosing crystalline limestone. For these reasons, the vein is likely to persist in depth, and may prove to possess economic dimensions.

## Frontenac County

### Township of Loughborough

*Concession XII, lot 5.*—This property lies about 10 miles by road east of Verona station, on the Kingston and Pembroke branch of the Canadian Pacific railway—3 miles of this distance being bush road. The distance from Hartington—the next station south of Verona—is about 6 miles, but this route can only be used in winter. The owner is Frank Grainger, Desert Lake P.O., Ont.

[1] Mines Branch Summary Report, 1910, p. 93.

A small pit was opened here, in 1907, by W. Morden, of Belleville, who extracted a few tons of ore, but made no shipments. No further work has been done.

The ore-body is exposed in the bottom of a small depression, its strike being northeast, following the course of the depression. The ridge on the west side consists of Grenville crystalline limestone, while that on the east side is composed of gneiss, dipping about 40° southeast. The character of the deposit suggests that it has been formed upon a faulted zone, at or near the contact of the limestone with the gneiss, but the amount of work done is insufficient to indicate its true extent. The ore-body consists of a mass of rather loosely intergrown, tabular, crystals of baryto-celestite, forming the cementing material between brecciated fragments of crystalline limestone. The latter have undergone pronounced alteration, and are, in part, recrystallized. Many of the fragments have suffered partial solution, the resulting cavities being lined with well crystallized calcite and acicular crystals of baryto-celestite. The bulk of the baryto-celestite is pure white, opaque, and breaks up readily into tabular, cleavage pieces.

The following analysis of a grab sample, taken from the stock pile and analysed in the Mines Branch laboratory, indicates the composition of the ore:—

| | |
|---|---|
| Barium sulphate | 15·02 |
| Strontium sulphate | 75·90 |
| Calcium carbonate | 7·32 |

A representative sample of the ore ground to pass 200 mesh, unbleached, and tested for colour against a standard sample of prime white, paint barytes, proved equal if not superior to the standard.

The large amount of brecciated limestone and secondary calcite in the ore-body, as exposed in the only opening on the property, precludes the possibility of cobbing the ore economically, and a clean product could only be secured by subjecting it to some system of concentration.

Further development work is required to prove up the deposit satisfactorily.

## Leeds County

### Township of Lansdowne

*Concession VIII, lot 2.*—Situated 5 miles south of Lyndhurst station, on the Brockville-Westport branch of the Canadian National railway. The deposit lies alongside the Long Point-Lyndhurst road. The owner is Charles O'Connor, of Kingston.

Two small pits were opened on the vein many years ago; no further mining has taken place. The largest of these openings is 40 feet long, 5 feet wide, and 20 feet deep. It discloses a vertical vein of celestite, 1 to 2 feet wide, striking northwest, and enclosed in silicated, Grenville crystalline limestone. There is no sharp line of demarcation between the vein and the country rock, the ore-body grading into the limestone. The celestite occurs as a rather loose aggregate of clear, lustrous, tabular crystals, of a prevailing bluish colour; but brown, and colourless crystals are also common. The narrowness of the vein, and the rather friable nature of the enclosing limestone, would render it difficult, in mining, to prevent the celestite becoming contaminated by calcite.

Analyses of the celestite show it to be exceedingly pure strontium sulphate:—

| | 1 | 2 | 3 |
|---|---|---|---|
| Strontium sulphate | 97·80 | 99·82 | 99·40 |
| Barium sulphate | 0·37 | ...... | ...... |
| Calcium sulphate | 0·97 | ...... | ...... |

1. Sample taken in bottom of large pit: analysed in Mines Branch laboratory.
2. Selected material: analysed[1] in Geological Survey laboratory.
3. Average sample of lead in bottom of large pit: analysed by Dominion Sugar Company, Chatham, Ont.

A representative sample of the celestite ground to pass 200 mesh, unbleached, and tested for colour against a standard sample of prime white, paint barytes, showed a faint grey coloration.

This deposit, on account of its narrowness, and also of the friable nature of both vein filling and country rock, which renders contamination of the celestite by calcite inevitable in mining, can hardly be considered of present economic importance.

## Renfrew County

### Township of Bagot

*Concession X, lot 7.*—The deposit of celestite occurring on this property is the most important known in Canada, and has been the most actively exploited. While intermittent mining has been conducted for a number of years, it is only since 1918 that any important development has been undertaken. Work is proceeding at the present time (November, 1920) and several carloads of cobbed celestite have been shipped. In addition, a small mill has been erected, and a little ground celestite has been produced.

The property is situated 5 miles by road southeast of Calabogie station, on the Kingston and Pembroke branch of the Canadian Pacific railway. One mile of this distance is mine road. The present operators are Messrs. Wilder and Bambrick, 354 Bleury street, Montreal, and the property is owned by the H. Robinson and C. R. McGregor estates, Ottawa. The deposit lies on fairly level land, a few hundred yards from the shore of Virgin lake; the low ridge on which the workings are situated rising only a few feet above the surrounding swampy ground. The overburden is generally light; the property carries considerable small timber.

The deposit is of an unusual type, both in the character of the ore, and its mode of occurrence. The celestite occurs in irregular, slab-like, masses of radiated, columnar or fibrous crystals, enclosed in brown dolomite. The dolomite displays indistinct parting planes, which dip 45°–60° southwest, and appear to be the result of lateral thrust or compression, rather than bedding planes. The rock was originally normal, Pre-Cambrian crystalline limestone, which has probably been altered to its present state by the ascending solutions from which the celestite was deposited. That these solutions had their source in a dike of diabase, intrusive into the limestone, seems probable from the occurrence along the foot-wall of the deposit of a narrow stringer of diabase. This stringer is merely a few inches wide, and is exposed at only two places; its presence, however, in such close proximity to the ore-body, suggests that a larger mass exists in depth.

[1] Geol. Surv. Can., Ann. Rep., Vol. VII, 1896, p. 9R.

The larger masses of celestite take on a vein-like character, and it is probable that the deposit, in depth, will assume true vein form. The irregular distribution of slab-like masses of celestite through dolomite, at the surface, suggests that the ore-body and enclosing rock have been subjected to considerable dislocation, under pressure, and that what was originally a vein, or series of anastomosing veins of celestite, has been ruptured and resolved into a dolomite-celestite breccia. (See Plates XI and XII, and Fig. 17.) While the bulk of the celestite masses average from a few inches to one foot thick, exceptionally large masses, measuring up to 2 and 3 feet, are sometimes encountered. As will be seen from Plate XII, the position of some of the larger masses suggests that they were originally parts of a saddle-vein. The operators report that in putting down a 60-foot vertical drill hole through the drift cover overlying the hanging-wall, about 14 feet of mixed celestite and dolomite was encountered, the celestite being in bands 2 to 3 feet thick. The hole was still in ore when drilling was discontinued.

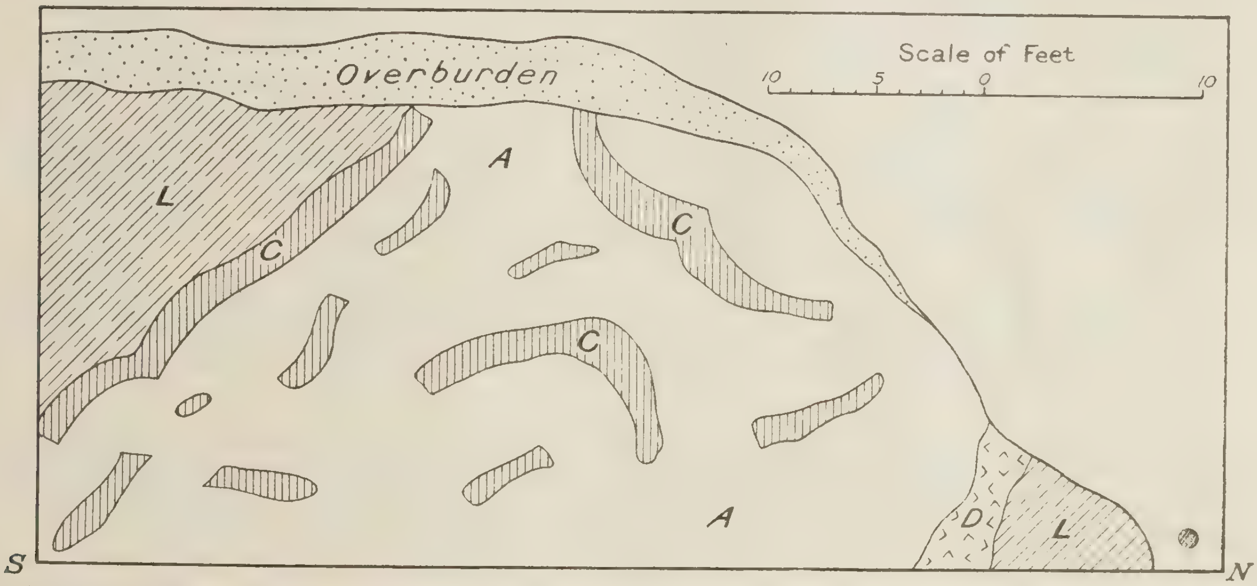


Fig. 17.—Diagrammatic section through celestite deposit, lot 7, concession X, Bagot township, Ontario. L, crystalline limestone; C, celestite; D, diabase dike; A, dolomite.

Practically all of the development work on the deposit has taken place on the hanging-contact, where the strongest indications of celestite are found; and the ground being drift-covered on the foot-wall side, there was no opportunity to determine the rock relationships. From exposures in the main pit, and examination of the various outcrops, however, it appears probable that the character of the deposit is somewhat as indicated, in a general way, in Fig. 17. That the diabase dike shown in the section is the source of the celestite, appears probable. It is equally probable that the brecciated character of the ore-body will give way in depth to a more regular vein formation.

Mining operations are confined to one open pit, 50 feet long, and 30 feet deep, opened in the face of the low ridge upon which the deposit outcrops. The strike of the ore-body follows the course of this ridge, which runs approximately east and west, and the dip is into the ridge. The intention of the operators is to sink an inclined shaft on the hanging-contact, from which drifts will be run along the more promising showings. A small

steam plant supplies power for drills, derrick-hoist, and pump. Trenching has exposed the deposit for a distance of 200 feet to the southwest of the main pit, and outcrops of celestite occur 1,000 feet to the northeast. There is every indication, therefore, that a very considerable ore-body exists. The total width of the brecciated ore-zone at the main pit, is 45 feet.

Present operations are concerned only with the recovery of the clean celestite that can be obtained with a minimum of rough cobbing. Possibly about 30 per cent of the total celestite present in the deposit can be reckoned as recoverable by this means, the remaining 70 per cent being so mixed with adhering dolomite, as to render milling of the ore necessary. The amount of celestite present over the entire width of the ore-zone exposed at the surface, is probably not over 10 per cent. The amount present in the zone now being worked, which represents a width of about 15 feet along the hanging-contact, may be as high as 20 per cent.

The large proportion of impure celestite going at present to the dump, makes it imperative for the successful operation of the deposit that some method of recovering the celestite content of this material be employed. Accordingly, a shipment of 2,000 pounds of mixed celestite and gangue was sent to the Ore Dressing laboratory of the Mines Branch for experimentation, to determine how the material could best be treated. The following data are taken from the report on the test conducted. Analysis of the ore showed 50·51 per cent of combined sulphates of barium and strontium, and 44·50 per cent of calcium carbonate.

In conducting the concentration tests on this ore, it was thought advisable to obtain as much clean celestite as possible, in a coarse form; and as the celestite crushed much more easily than the gangue, care was taken in the crushing to make a minimum amount of fines.

The ore was crushed to 2″ in a jaw breaker, and run over a Ferraris screen fitted with 1″ and ¼″ screens. A head sample was cut out by a Vezin sampler, through which the flow passed onto the screen. The oversize, +1″, was run over a picking belt, and the clean celestite picked out. The +1″ mixed ore was then passed through rolls, and crushed to pass the 1″ screen. From the above operation, the following products were obtained:—

| Product | Weight pounds | Analysis | | Content, pounds | | Percentages of values | |
|---|---|---|---|---|---|---|---|
| | | Celestite | Calcite | Celestite | Calcite | Celestite | Calcite |
| Hand picked | 163 | 89·52 | 9·50 | 145·9 | 15·5 | 16·5 | 2·0 |
| 1″ | 802 | 35·62 | 58·88 | 285·7 | 472·2 | 32·3 | 60·7 |
| ¼″ | 741 | 57·83 | 36·60 | 428·5 | 271·2 | 48·5 | 34·8 |
| Dust loss | 43·5 | 54·25 | 45·06 | 23·6 | 19·6 | 2·7 | 2·5 |
| Ore | 1,749·5 | 50·51 | 44·50 | 883·7 | 778·5 | 100·0 | 100·0 |
| Head sample | 205·0 | 50·51 | 44·50 | | | | |
| To crusher | 1,954·5 | 50·51 | 44·50 | | | | |

Both the − 1″ and − ¼″ products were concentrated by passing them through a James jig. The hutch products from the jig were tabled to determine whether they could not be improved. The results were, however, unsatisfactory. With the jigs in proper adjustment, a 90 per cent hutch product should be made.

The jig test on the $-\frac{1}{4}''$ product gave the following results:—

| Products | Weight pounds | Analysis | | Content, pounds | | Percentages of values | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Celestite | | Calcite | |
| | | Celestite | Calcite | Celestite | Calcite | ¼″ | Crude | ¼″ | Crude |
| Conc. No. 1 jig.......... | 25·5 | 91·40 | 5·85 | 23·3 | 1·5 | 5·7 | 2·8 | 0·6 | 0·2 |
| Conc. No. 2 jig.......... | 77 | 92·06 | 4·31 | 70·09 | 3·3 | 17·4 | 8·4 | 1·3 | 0·4 |
| Conc. table.............. | 287 | 83·48 | 14·73 | 239·6 | 42·3 | 58·6 | 28·4 | 16·3 | 5·7 |
| Tail. table.............. | 2·5 | 38·07 | 54·09 | 1·0 | 1·4 | 0·2 | 0·1 | 0·5 | 0·2 |
| Tail. jig................ | 275 | 22·59 | 71·40 | 62·1 | 196·3 | 15·2 | 7·4 | 75·5 | 26·3 |
| Jig bed.................. | 20 | 60·32 | 33·07 | 12·1 | 6·6 | | | | |
| Slime loss............... | 41 | 29·27 | 36·59 | 12·0 | 15·0 | 2·9 | 1·4 | 5·8 | 2·0 |
| Totals.......... | 728 | 57·83 | 36·60 | 421·0 | 266·4 | 100·0 | 48·5 | 100·0 | 34·8 |

The values yielded by the jig test on the $-1''$ product were as follows:—

| Products | Weight pounds | Analysis | | Content, pounds | | Percentages of values | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Celestite | | Calcite | |
| | | Celestite | Calcite | Celestite | Calcite | 1″ | Crude | 1″ | Crude |
| Conc. No. 1 jig.......... | 51·5 | 91·73 | 6·32 | 47·2 | 3·3 | 18·3 | 5·9 | 0·7 | 0·4 |
| Conc. No. 2 jig.......... | 86 | 90·33 | 8·19 | 77·7 | 7·0 | 30·1 | 9·7 | 1·6 | 1·0 |
| Hutch No. 1 jig.......... | 59·5 | 86·20 | 12·20 | 51·3 | 7·3 | 19·8 | 6·4 | 1·7 | 1·0 |
| Hutch No. 2 jig.......... | 10 | 76·88 | 20·64 | 7·7 | 2·1 | 3·0 | 1·0 | 0·5 | 0·3 |
| Tail. jig................ | 506 | 14·72 | 79·38 | 74·5 | 401·7 | 28·8 | 9·3 | 92·0 | 55·9 |
| Jig bed.................. | 22 | 56·40 | 40·38 | 12·4 | 8·9 | | | | |
| Slime loss............... | 22 | 0·00 | 70·00 | 0·0 | 15·4 | 0·0 | 0·0 | 3·5 | 2·1 |
| Totals.......... | 757 | 35·62 | 58·88 | 269·6 | 445·7 | 100·0 | 32·3 | 100·0 | 60·7 |

Summary:—

| Product | Percentage Celestite | Percentage of total Celestite |
|---|---|---|
| Hand picked.......... | 89·52 | 16·5 |
| Conc. No. 1 jig, −¼″.......... | 91·40 | 2·8 |
| Conc. No. 2 jig, −¼″.......... | 92·06 | 8·4 |
| Table conc.......... | 83·48 | 28·4 |
| Conc. No. 1 jig, −1″.......... | 91·73 | 5·9 |
| Conc. No. 2 jig, −1″.......... | 90·33 | 9·7 |
| Hutch No. 1 jig, −1″.......... | 86·20 | 6·4 |
| Hutch No. 2 jig, −1″.......... | 76·88 | 1·0 |
| Total recovery.......... | .......... | 79·1 p.c. |

Conclusions:—

Hand picking should be resorted to, as the celestite breaks away quite freely from the gangue, and a clean celestite product can be obtained, representing 16·5 per cent of the values.

By jigging the $-1''$ and $-\frac{1}{4}''$ material after hand picking, the jig concentrates obtained were equally as good as the hand picked product, consequently, with careful manipulation of the jigs, and after obtaining the proper adjustments, a hutch product should be made practically as good as the concentrates.

The recovery of an ore of the grade submitted should be between 75 and 80 per cent.

The celestite is opaque, and uniformly of a good white colour, very little of the ore being stained by iron or other impurities. Outside of the dolomite gangue matter, and a little calcite on crevices, no other mineral impurities occur. No trace of sulphides was noticed. As already stated, the celestite occurs as aggregates of thin, interlacing, radiated, columnar crystals.

The ore is soft, and breaks down readily into powder. While referred to in this report as celestite, the material should more properly be termed baryto-celestite; for a considerable percentage of barium is present. The following analyses indicate the composition of the ore:—

| | 1 | 2 |
|---|---|---|
| Strontium sulphate | 85·63 | 78·50 |
| Barium sulphate | 14·38 | 18·61 |
| Calcium sulphate | Trace | 0·73 |

1. Selected material: analysed by R. A. A. Johnston, Geological Survey.
2. Representative sample from stock pile: analysed by E. A. Thompson, Mines Branch.

The specific gravity of the material is 3·99.

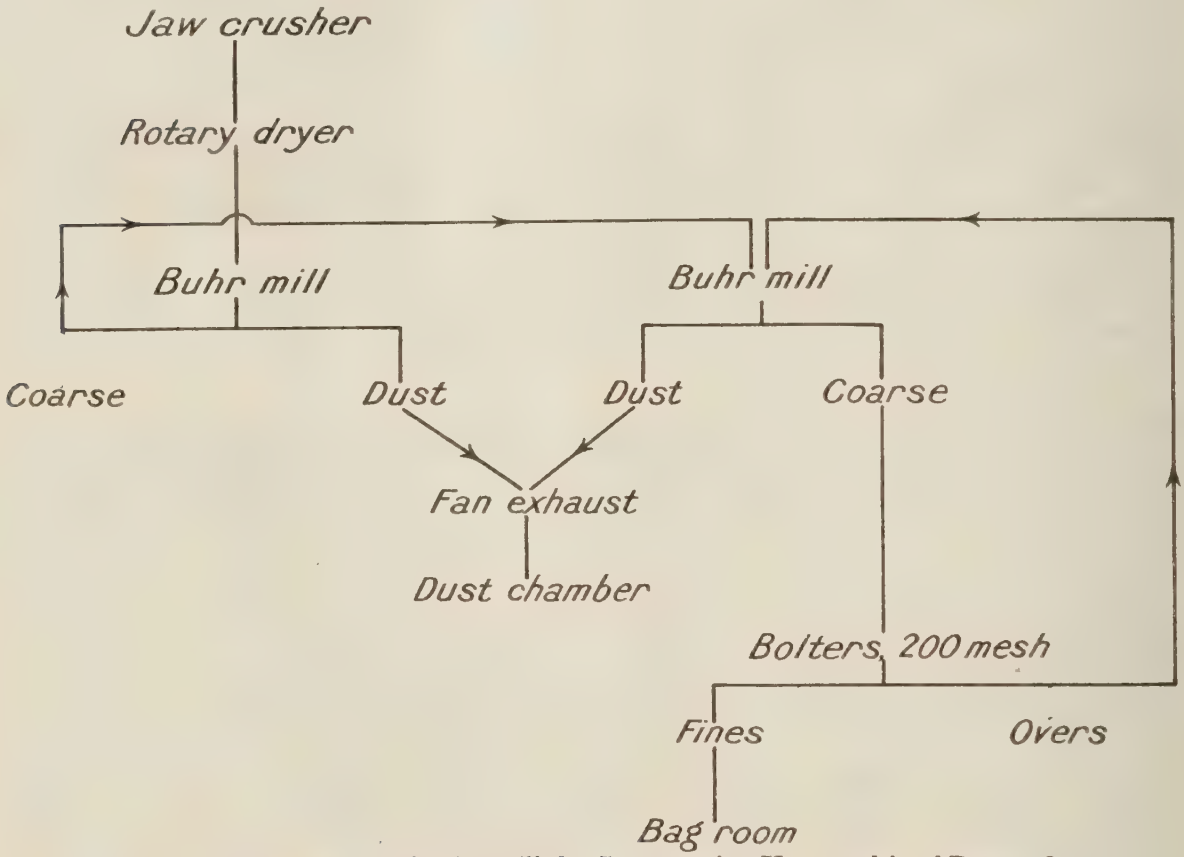


Fig. 18.—Flow sheet of celestite mill, lot 7, concession X, township of Bagot, Ont.

The high barium content is stated to render the celestite unsuitable for use in the refining of beet sugar, which industry consumes large quantities of strontium oxide. The material, however, would probably prove suitable for many purposes where barytes is now used, such as in the paint, paper, and rubber trades. The operators report that the celestite is being successfully employed to replace barytes in paint, several shipments having been made to the paint trade.

A representative sample of the celestite ground to pass 200 mesh, unbleached, and tested for colour against a standard sample of prime white, paint barytes, proved barely distinguishable from the standard.

### *Mill*

During 1920, the present operators erected a small mill (Plate XIII), and commenced grinding the cobbed celestite. Up to the time of writing (November, 1920), work has been of an experimental nature, and no ground products have been shipped. The mill system employed is as shown in Fig. 18. The cobbed ore is fed to a jaw crusher, and reduced to coarse sand size. It is then dried in a rotary shell drier, heated by steam coils, and fed to a buhr mill. A fan exhaust draws the dust from this mill, and deposits it in a dust chamber. The coarse proceeds to a second buhr mill, connected with the same exhaust fan, the dust from it, also, being blown into the dust chamber, while the coarse goes to two hexagonal bolters fitted with 200-mesh cloth. The throughs from the bolters go to the bag room, and the overs return to the second buhr mill. Over 90 per cent of the dust deposited in the dust chamber is said to pass 200 mesh. This grade is designed for the paint trade, and the product of the bolters for the rubber trade.

## Minor Occurrences

### BRITISH COLUMBIA

An unusual occurrence of celestite is reported by R. P. D. Graham[1] near Birch island, North Thompson river, on the Canadian National railway, 80 miles north of Kamloops. A band of opaque, violet fluorite is here found traversing an intrusion of quartz porphyry into a schist formation. This band appears to have a width of from 1 to 2 feet.

On analysis, the violet-coloured vein matter was found to have a remarkable composition, and proved to be essentially a mixture of fluorite and celestite. The analyses given below indicate the composition of the material:—

| | 1 | 2 |
|---|---|---|
| Calcium fluoride | 47·20 | 51·11 |
| Strontium sulphate | 32·30 | 26·29 |
| Calcium carbonate | 2·50 | 1·84 |
| Iron sulphide | 3·70 | 0·54 |
| Ferric oxide | ...... | 1·18 |
| Alumina | 3·00 | 2·19 |
| Silica | 6·50 | Not determined |
| Undetermined | 4·80 | 16·85 |

1. Average sample: analysed in Ore Dressing laboratory, Mines Branch.
2. Average sample, with pyrite removed: analysed by R. P. D. Graham, McGill University.

Under the microscope, the material is seen to consist of finely crystalline, purple fluorite, having interspersed through it colourless celestite.

Experiments on a sample of the ore were carried out in the Ore Dressing laboratory of the Mines Branch, in order to see whether the celestite and pyrite could be removed, and a clean fluorite obtained. The results showed that the pyrite present cannot be removed satisfactorily either by tabling or by flotation; a combination of the two should give good results. The celestite apparently cannot be eliminated by ordinary concentration methods.

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[1] Munitions Resources Commission of Canada, Final Report, 1920, pp. 49–52.

## NOVA SCOTIA

### Cape Breton County

A deposit of celestite is reported[1] to occur on the right bank of Sydney river, about 1½ mile above Sydney Bridge. The material is stated to consist of bluish-grey, massive, celestite, forming a bed one foot thick, in Carboniferous limestone. The writer visited the locality and examined both banks of the river below the Dominion Iron and Steel Company's dam, but was unable to locate the bed. Mr. H. Piers, curator of the Halifax museum, states that he has also endeavoured to trace the deposit without success.

## ONTARIO

In Volume XIII, 1900, of the Geological Survey, p. 174A, a specimen of celestite is stated to have been donated by Thomas Ross, of Little Rideau, the locality being given as "Little Rideau river, Hawkesbury, in Prescott county." The writer visited this locality, but was unable to trace the occurrence. Mr. Robert Ross, of Little Rideau, states that a vein of celestite is supposed to occur on lot 28 in concession I, township of East Hawkesbury, but that he has never been able to locate the deposit. He also reports that R. W. Ells and H. Ami, of the Geological Survey, endeavoured some years ago to trace the occurrence, but were unsuccessful.

Masses of radiated celestite are stated to occur in magnesian limestone of the Hudson River formation on the east side of Manitouaning bay, and at Cape Robert, Grand Manitoulin island. (Geol. Surv. Can., Vol. XII, 1899, p. 19R.)

Small nodular masses of red celestite occur in the limestone of the Fleming quarry, concession X, lot 26, township of Esquesing, Halton county, near Georgetown. (Geol. Surv. Can., Memoir 74, p. 53.)

Baryto-celestite occurs as masses of radiated, fibrous, white crystals, associated with barytes and fluorite, on lot 10, concession XII, of the township of Huntingdon (Blakeley mine), Hastings county. A sample of this baryto-celestite, analysed in the Mines Branch laboratory, yielded:—

| | |
|---|---|
| Strontium sulphate | 85·10 |
| Barium sulphate | 11·79 |
| Calcium sulphate | 1·94 |

Celestite also occurs on lot 9, concession XIV, of the same township, as well as at other of the fluorite mines in the Madoc district.

Crystals of celestite have been obtained from an excavation in the bed of the Detroit river, at Amherstburg, Essex county. (Geol. Surv. Can., Vol. XVI, p. 347A.)

Fibrous, pink celestite occurs near Marmora, Hastings county.

Platy, red celestite is found as inclusions in limestone at the forks of the Credit river, Caledon township.

Massive, white and blue celestite occurs near Gananoque, Leeds county.

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[1]Geol. Surv. Can., Rep. Prog., 1875-76, pp. 399, 417; Ann. Rep., Vol. VI, 1892, p. 25R.

## STRONTIANITE

Strontianite, or strontium carbonate, is not known to occur in economic quantity in Canada, the three known occurrences of this mineral being of mineralogic interest only.

### BRITISH COLUMBIA

Pale green, translucent strontianite is reported to occur as a crust, and also in concretionary masses, in the gravel and Tertiary shales of the Horsefly river, Cariboo district. (Geol. Surv. Can., Vol. VI, p. 30R.) It is also found on the Defiance claims, on the Skagit river, near Hope, Yale mining division. (Ann. Rep. Minister of Mines, B.C., 1920, p. 171.)

### ONTARIO

### Carleton County

#### Township of Nepean

*Concession A, lot 31.*—This locality is described[1] as on the south shore of the Ottawa river, a short distance below the road leading down to the old Skead mill. The deposit occurs below high water mark and can only be seen when the water in the river is low.

The occurrence is of mineralogic interest only. It was not examined by the writer, but in Vol. VI of the Geological Survey, 1892–3, p. 22R, the deposit is stated to consist of two narrow veins, about 6 inches wide, traversing Chazy limestone. Vein pieces, collected by A. T. McKinnon, of the Geological Survey, and examined by the writer, consisted largely of calcite and brecciated fragments of limestone. Occurring irregularly in this material, and occasionally extending almost the entire width of the vein, are aggregates of radiating, fibrous strontianite crystals. The strontianite probably does not form more than 20 per cent of the vein filling. The material is of a pale, yellowish-green colour, grading into white. Associated with it is a small amount of pyrite. Analysis of carefully selected material, made in the laboratory of the Geological Survey, showed 93·4 per cent of strontium carbonate, the residue being calcium carbonate. Analysis of similar material, made in the Mines Branch laboratory yielded:—

| | |
|---|---|
| Strontium carbonate | 91·66 |
| Calcium carbonate | 7·96 |

### QUEBEC

White, fibrous strontianite is stated to occur in calcareous nodules in the Utica shale of St. Helen island, Hochelaga county. (Geol. Surv. Can., Vol. IV, p. 61T.)

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[1] Geol. Surv. Can., Ann. Rep., Vol. XII, 1899, p. 44G.

# CHAPTER II

## SOURCES OF STRONTIUM

The two commercial sources of strontium are the minerals celestite (strontium sulphate) and strontianite (strontium carbonate). Celestite is by far the more common, and constitutes the bulk of the raw material used in the production of strontium salts.

### Celestite

Celestite is usually a white, cream-coloured or bluish mineral. It commonly occurs in tabular crystals, resembling barytes, and is also found in aggregates of fibrous or columnar crystals. Its hardness is the same as that of barytes, 3 to 3·5. It is a little lighter than barytes, the specific gravity being 3·9 as compared with 4·5 for barytes.

When pure, celestite contains 56·4 per cent of strontia and 43·6 of sulphur trioxide. The mineral is readily distinguished from barytes by the flame test. Powdered celestite, moistened with hydrochloric acid, and heated on a platinum wire, imparts a characteristic crimson coloration to a flame, while barytes colours the flame green.

The chief sources of the world's supply of celestite are the Bristol district, in England, and Sicily. In the former district, the celestite occurs as nodular masses and irregular beds in marl; in Sicily, it is found associated with sulphur and gypsum.

An average of 29 analyses of English celestite yielded 91·1 per cent of strontium sulphate. English celestite is unsalable if the content falls below 90 per cent.[1]

For many years prior to the war, England supplied the bulk of the world's output of celestite, the average annual production from 1884 to 1914 being about 13,000 tons. That most of this celestite probably went to continental beet sugar works is indicated by the fact that the outbreak of the war brought about a drop in production from 13,000 tons, in 1914, to 600 tons in 1915, and that during the period 1915–19 the annual output averaged less than 2,000 tons.

Most of the output during the war period found a market in the United States. In 1919, the average price of the English celestite imported into the United States was $22.75 per ton.[2] The chief product manufactured from this celestite was strontium nitrate, for use in pyrotechnics and signal lights. Strontium carbonate was also made in quantity, most of it as an intermediate product in the preparation of other strontium salts, but some also for experimental purposes in sugar refining. Among other strontium salts prepared, were the bromide, chloride, hydroxide, sulphate, iodide, and salicylate.

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[1] Special Reports on the Mineral Resources of Great Britain, Geological Survey Office, Vol. III, 1915, pp. 46, 54.

[2] Mineral Resources of the United States, 1919, Part II, p. 96.

The Sicilian celestite deposits appear to be worked sporadically, according to the market; any material rise in the price of celestite resulting in Sicilian mineral being offered. Under normal conditions, the Sicilian deposits, on account of transportation difficulties, are unable to compete with the English deposits.

### Strontianite

Strontianite is a more valuable mineral than celestite, since it is readily soluble in acids and may be converted into other strontium compounds more easily than celestite. By simple calcination, it is converted into the oxide. Weight for weight, also, strontianite contains more strontium than celestite. Pure strontianite contains 70·3 per cent of strontia, whereas pure celestite contains only 56·4 per cent. This latter advantage, however, is offset by the fact that most strontianites have a proportion of their strontia replaced by lime, whereas many celestites are practically pure strontium sulphate. Strontianite commands a higher market price than celestite.

Strontianite is a white, yellow, or greenish mineral. It usually occurs in aggregates of radiated, columnar or fibrous crystals, resembling aragonite (calcium carbonate) in its general appearance, but distinguishable from this mineral by its greater weight. Strontianite imparts a characteristic red coloration to the flame when strongly heated, but this test is not always conclusive, owing to the possible presence of calcium carbonate, which masks the coloration; the strontium coloration may be accentuated by moistening the powdered mineral with hydrochloric acid.

Strontianite is a relatively rare mineral, and very few occurrences of it in economic quantities are known. The most important source of strontianite is the Muenster and Hamm district, in Westphalia, Prussia. The deposits of this region were formerly worked extensively and supplied the strontianite used in the preparation of strontium hydroxide for the German beet sugar industry. Prior to the war, production from this region had almost ceased, owing to the competition of English celestite. The Muenster strontianite occurs as the filling of relatively shallow, vertical veins, in Cretaceous beds.

Strontianite sometimes occurs as a gangue mineral on metalliferous veins, as in the Harz mountains, in Germany, and at Strontian, in Scotland. It has also been found in the form of irregular masses in clay, near Barstow, California.

## USES OF STRONTIUM

The chief use of strontium is as strontium hydrate in the beet sugar industry. Strontium salts are also used in pyrotechny for making "red fire," for signal flares; in chemical reagents; and in medicine. Strontium carbonate is used in the manufacture of iridescent glass.

In recent years, celestite has been employed to some extent as a substitute for barytes as a loader or filler. It is also reported to have been used with success in place of barytes as a base in the manufacture of lithopone.

G. W. Stose[1] instances the use of strontium for hardening copper castings. The copper-strontium alloy is obtained either by adding metallic strontium to the melt, or by electrolysis of fused strontium chloride, using a molten copper cathode.

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[1] Mineral Resources of the United States, 1919, Part II, p. 97.

The refining of beet sugar by the Scheibler, or strontia, process is largely confined to Europe. In the United States it is the Steffens, or lime, process that is chiefly used. The only refiners of beet sugar in Canada, the Dominion Sugar Company, with plants at Chatham, Wallaceburg, and Kitchener, Ontario, employ both the strontia and baryta methods. Since the strontium hydrate used in sugar refining is recovered to a great extent by regenerative processes, the annual requirements of the beet sugar industry are much smaller than might be imagined.

# REFERENCE BIBLIOGRAPHY

The principal sources consulted in the compilation of this report are given below. Minor references are given in the text. No attempt has been made to prepare a bibliography of the existing literature on barium and strontium, but many additional references to articles, reports, etc., dealing with the occurrence and technology of barytes, celestite and strontianite will be found in the publications listed.

1. Hull, J. P., Barytes Deposits of Georgia, Bull. No. 36, Geol. Surv. Georgia, 1920.
2. Knopf, A., Strontianite Deposits near Barstow, California, U.S. Geol. Surv., Bull. No. 6601, 1918, pp. 257–70.
3. Mineral Industry, Annual Volumes to date.
4. Poole, H. S., Barytes Deposits of Lake Ainslie and North Cheticamp, Nova Scotia, Mineral Resources Bull., No. 953, Geol. Surv. Can., 1907.
5. Sherlock, R. L., Celestine and Strontianite, Special Reports on the Mineral Resources of Great Britain, Memoirs of the Geological Survey, Vol. III, 1915.
6. Steel, A., Geology, Mining and Preparation of Barite in Washington County, Missouri, Bull. 38, Amer. Inst. Min. Eng., 1910, pp. 85–117.
7. Tarr, W. A., Barite Deposits of Missouri, University of Missouri Studies, Vol. III, No. 1, 1918. Contains a bibliography of literature relating to the occurrence and origin of barytes.
8. United States Geological Survey, Mineral Resources, Annual Volumes 1912 to date. The volume for 1914 contains a bibliography of the literature on the occurrence and technology of barytes, and the volume for 1915 has 25 pages dealing with the subject of barytes and barium and strontium products.
9. United States Tariff Commission, Tariff Information Series, No. 18, 1920, Barytes, Barium Chemical and Lithopone Industries, Including Costs of Production, 1919. Consists of 80 pages of data relating to the barytes and barium industries in the United States.

# INDEX

A



B

I



J



K



L



M

R



S



T



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PLATE I.

Barytes grinding mill of Barytes Ltd., at Scotsville, Cape Breton, Nova Scotia.

PLATE II.

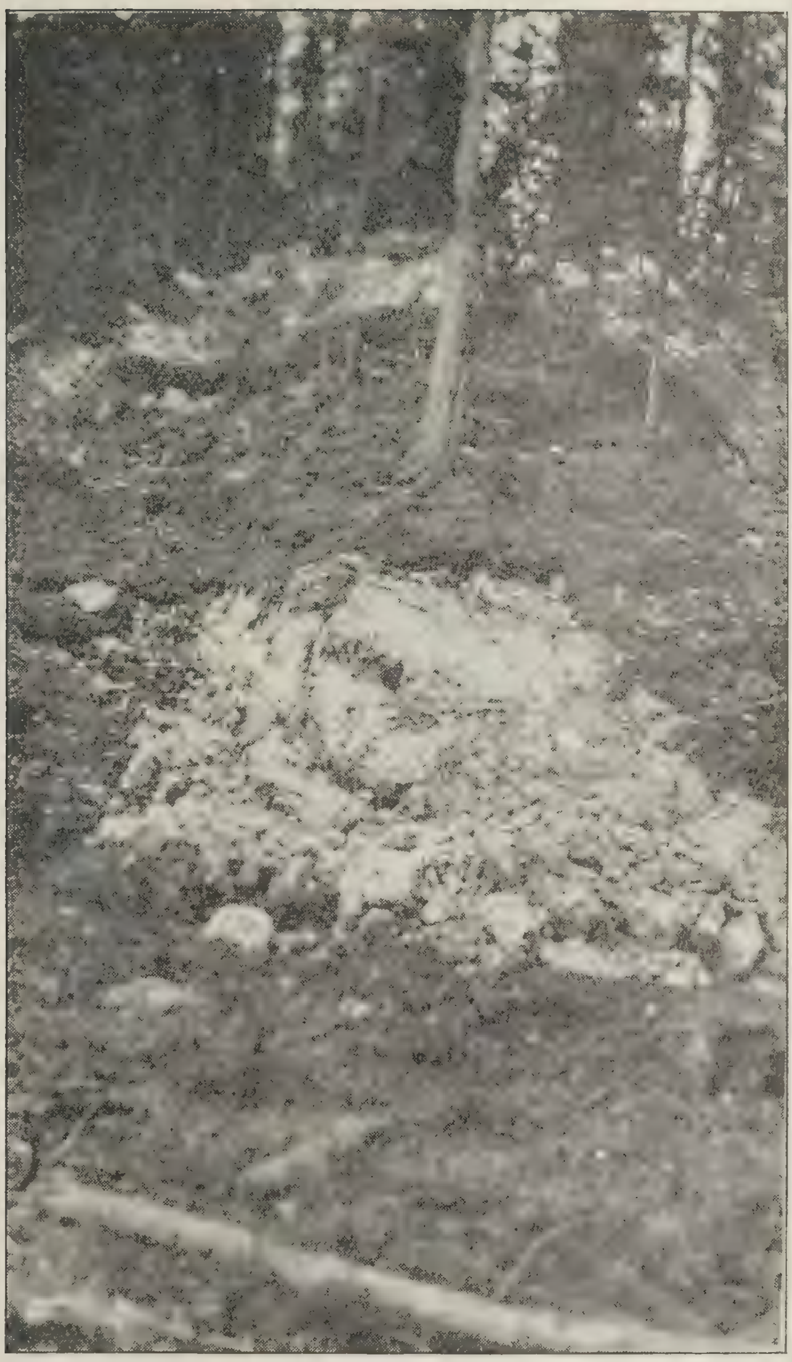
Buhr mills at mill of Barytes, Ltd., Scotsville, Cape Breton, Nova Scotia.

Plate III.

Barytes workings on Burnt hill, East Lake Ainslie, Cape Breton, Nova Scotia. The trend of the veins is indicated by the dotted line.

Plate IV.

General view of barytes occurrence near Tionaga, township of Penhorwood, Ontario, looking north from railway track. The ore-body extends for over 500 feet along the crest of the low ridge in the centre of the photograph, its course being indicated by the white line.



Barytes occurrence near Tionaga, township of Penhorwood, Ontario. The photograph shows the most northerly outcrop of the vein, which here passes under a swamp. The ore-body exhibits its maximum width of 16 feet at this point.

PLATE VI.

Barytes vein on Biederman claim, township of Cairo, Timiskaming district, northern Ontario. The vein as shown is 16 feet between walls, but contains much brecciated country rock.

PLATE VII.

Outcrop of barytes vein on Eby or Scott claim, township of Lawson, Timiskaming district, northern Ontario, looking west. The barytes of this deposit is of exceptionally good quality.

PLATE VIII.

Barytes vein on Mistinikon lake, township of Yarrow, Timiskaming district, northern Ontario, looking west. The vein here measures 14 feet between walls, but contains horses of country rock. Distance from rail hinders development of this and other northern Ontario barytes deposits.

Barytes occurrence at Premier Langmuir mine, township of Langmuir, Timiskaming district, northern Ontario. View taken prior to the erection of the mill shown in Plate X, and showing outcrop of the vein. A second vein is exposed in the face of the ridge to the left of the shed.

PLATE X.

General view of property of Premier Langmuir Mines Ltd., township of Langmuir, northern Ontario, showing mill and part of outcrop of vein.

PLATE XI.


Open pit on celestite deposit, township of Bagot, Renfrew county, Ontario. The bedded character of the limestone is shown, as well as what is assumed to be the main celestite body (A).

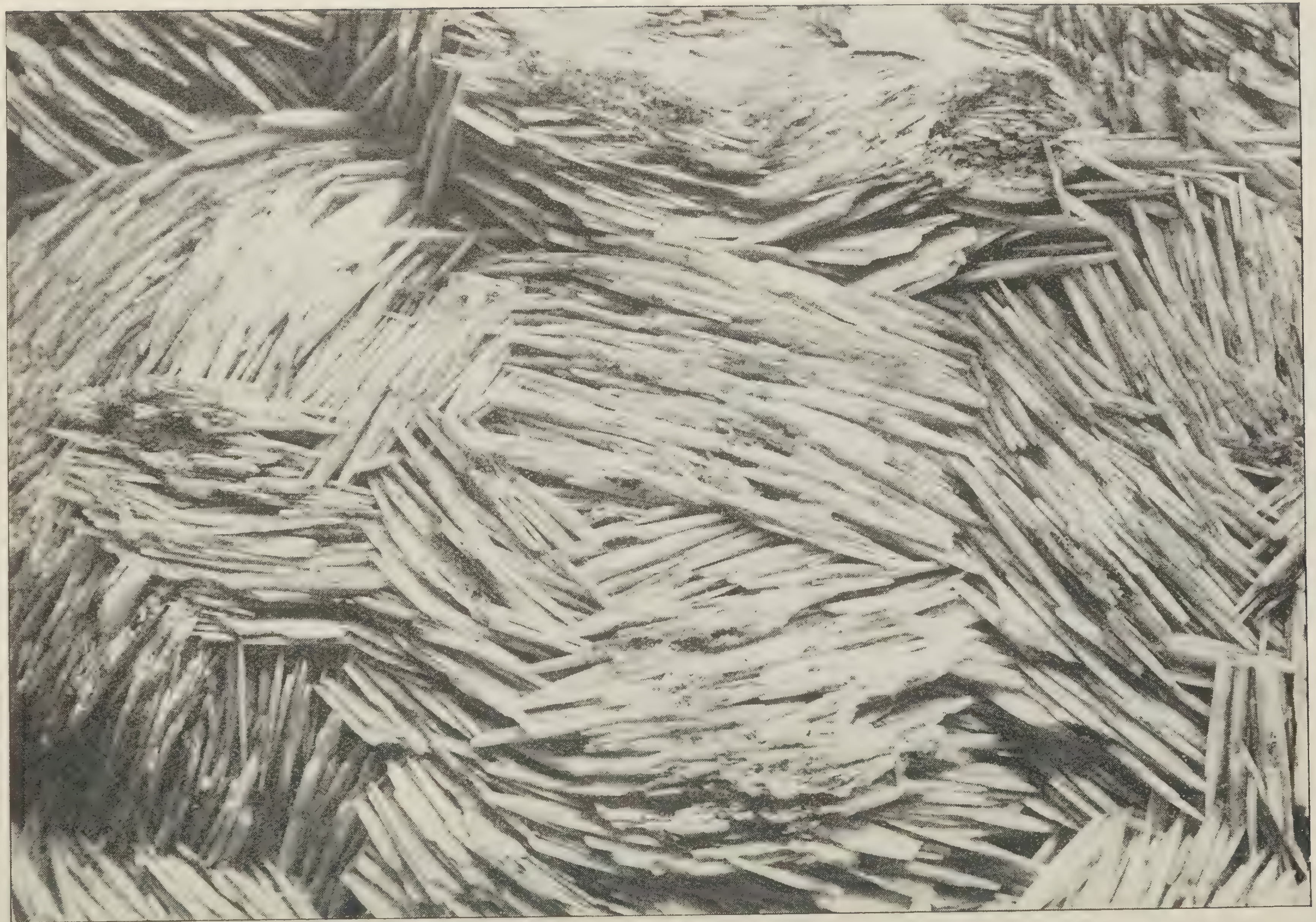
PLATE XII.

Open pit on celestite deposit, township of Bagot, Renfrew county, Ontario. The photograph shows the occurrence of the celestite (white) as irregular masses in limestone.

PLATE XIII.

Celestite grinding mill, township of Bagot, Renfrew county, Ontario.

Characteristic crystallization of barytes, showing aggregates of tabular crystals in semi-botryoidal grouping, Madoc, Ont.



Characteristic crystallization of barytes, known as "crested barytes", showing aggregates of thin tabular crystals arranged in sub-mammillary grouping. North Burgess, Ontario.

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